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Reinforced Concrete Ships

LAUNCHING OF STEAMSHIP FAITH GIVES IMPETUS TO CONCRETE SHIPBUILDING AS PARTIAL SOLUTION TO SHIP SHORTAGE

IN TIME OF EXTREME need, a crisis is frequently met by some previously unforeseen means. So apparently our necessity for ships, more ships and still more ships, will be met in part by ships whose hulls are made of reinforced concrete. This hope is stimulated by the launching of the 5000-ton steamship Faith in the bay at Redwood City, Calif., on March 14. Upon advice from the Shipping Board, as stated in the Official Bulletin for April 16, President Wilson has approved an estimate of appropriation of $50,000,000 for the acquisition or establishment of plants suitable for concrete shipbuilding and for building or acquiring concrete ships. Showing how rapidly progress is being made, an item in the Official Bulletin for April 27 states that the construction of the first concrete shipbuilding plant under government direction got under way on Wednesday, April 24, at Wilmington, N. C. There will be four ways and the company will build at least eight ships of 3500 and 7500 tons. The first ships are scheduled to be launched there in October. It is proposed to build five government shipyards for concrete ship construction, probably two on the Atlantic, two on the Pacific and one on the Gulf coasts.

With the rapid growth of a fleet such as is planned by the government, comes the call for marine engineers and power plant men and it is highly probable that many engineers of stationary plants will find a field of service to their liking in the concrete ships now being planned and built.

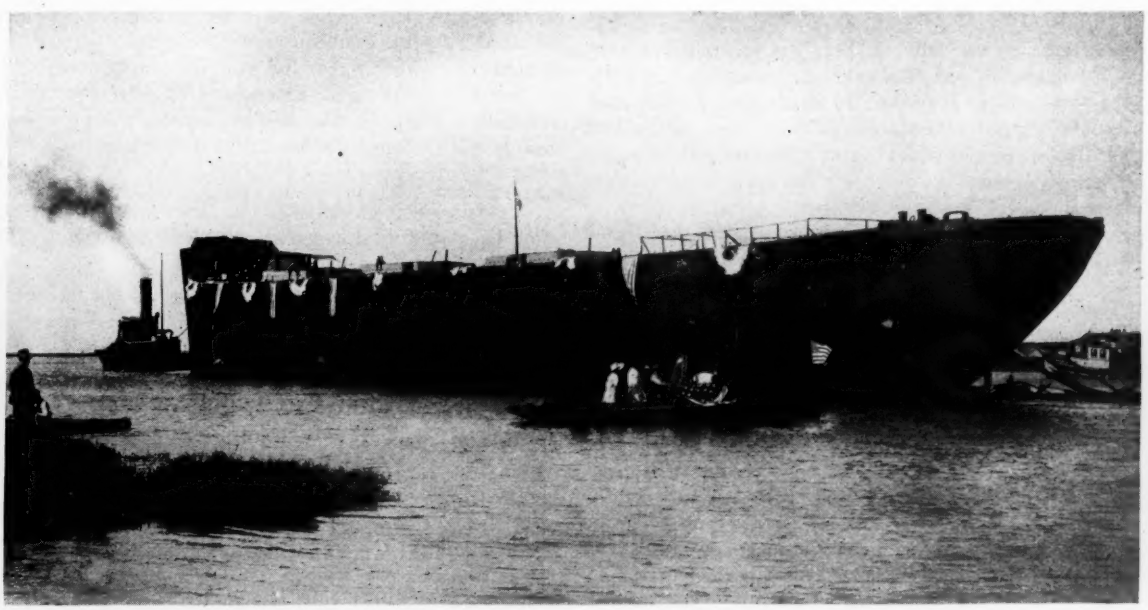


FIG. 1. TOWING HULL OF THE FAITH FROM PLACE OF LAUNCHING TO PLACE WHERE MACHINERY IS BEING INSTALLED

HISTORICAL SKETCH

REINFORCED concrete is not a new material for water-going vessels. Strange as it may seem, the first use of reinforced concrete was in a rowboat built in France in 1849, and it is stated that this boat is still in service. There seems to be no record of larger sizes of boats

made of this material until in 1887, when the sloop De Zeemeuw was built in Holland; it has been in constant service ever since, including work among ice, and is reported to be still in good condition.

In 1899 the construction of scows and barges was begun at Rome, Italy, and the process developed to such an extent that in 1905 a barge of 150 tons was constructed. Other barges of similar size were given severe tests by being driven against piling and rammed by a steel towboat with such satisfactory results as to warrant further construction.

In 1909 a barge or lighter of 220 tons was built in Frankfort-on-Main for the transport of gravel. In 1910

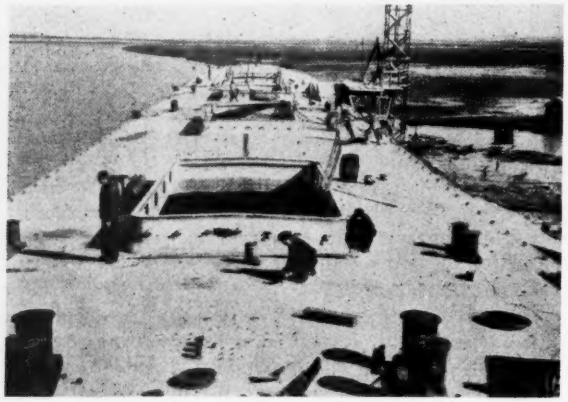


FIG. 2. DECK VIEW OF THE FAITH LOOKING TOWARDS STERN

a concrete scow was built in San Francisco 100 ft. by 30 ft. 7 in., and of 525 tons carrying capacity. In 1911 barges were built at Panama and Baltimore. In England construction apparently started in 1910, when the hull of a river dredge was built and later a pumping lighter.

Among the most interesting reinforced concrete ship construction work done in recent years is that in Norway, where one company has built some 18 to 20 lighters and towboats. These lighters have a capacity of 100 to 200 tons, the later types having more the barge shape. It was this same company that built the first sea-going ship, the Namsenfjord, which was launched last year. It carries a cargo of 200 tons and is driven by a Bolinder crude-oil engine of 80 hp. at a speed of 7½ knots. It is reported that a 4000-ton ore carrier is now under contract which will be driven by two 300-hp. Diesel engines.

With such a record before it, the construction of the steamship Faith, which was recently launched, is not such a radical departure as might appear to the layman. True, it is the largest ship using reinforced concrete construction ever launched, intended for trans-oceanic service, and the exact effects upon the serviceability of the ship of various stresses put upon the structural members of the ship's hull, are largely matters of conjecture. Nevertheless, there can be little doubt as to the practicability of the material.

Disadvantages and Advantages

The principal disadvantages of reinforced concrete ships as summarized by Walter Pollock, of England, are: (a) Greater weight and consequently greater displacement for the same tonnage; (b) increase of net tonnage and consequent increase in port and harbor dues; (c) increased cost of building and launching ways; (d) longer time to repair if bottom repairs are necessary.

The advantages are: (a) Much less steel than is necessary for a steel vessel, and no waste due to scrap; (b) no loss of strength due to rivet holes and joining as in a steel vessel; (c) cheaper and quicker construction; (d) very little skilled labor, no platers, anglesmiths, or riveters required; (e) longer life and reduced depreciation; (f) reduced upkeep and repair bills; (g) freedom from dry rot as in wooden vessels and freedom from corrosion as in steel vessels; (h) smoother surface and less skin friction; (i) fireproof construction.

As is the case with all new developments or materials in competition with others, reinforced concrete ship construction would appear to have its limitations. At a recent meeting of the Institute of Naval Architects in England these limitations were stated as follows: For river craft, pontoons, floating drydocks, floating piers, etc., reinforced concrete construction will probably develop and become a permanent industry. For river and harbor lighters, tugs and coasting vessels, this form of construction will, if all the present experimental vessels are successful, probably remain a recognized form of construction for years to come. Steel vessels may come back to their own as soon as freights are low and competition keen. For larger vessels up to say 2000 tons deadweight capacity, reinforced concrete will no doubt prove a practical and commercial proposition for a few years. It is difficult, the author of the paper states, to see the advantage of using concrete in the case of the Faith, a 5000-ton ship, as the amount of steel required for reinforcing probably amounts to 75 per cent of that of a steel ship of the same deadweight capacity. It seems probable that immediately the really critical situation as regards steel and skilled labor is past, large vessels will no longer be constructed of concrete.

Suitability of Material

Taking up in detail the qualities of the material, it may be stated that concrete in itself is strong under

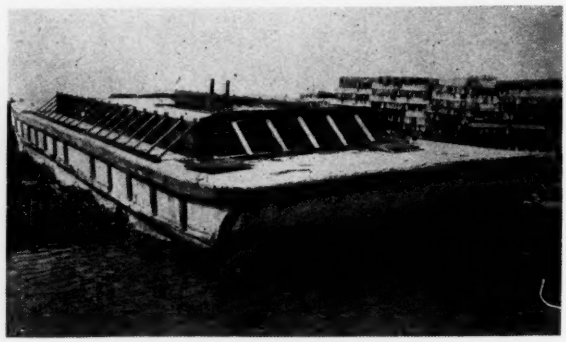


FIG. 3. BARGE OF ITALIAN TYPE BUILT AT MOBILE, ALA., 90 FT. LONG BY 26 FT. WIDE BY 9 FT. DEEP, WASHED ASHORE DURING A STORM, BUT SOON TO BE FLOATED. NOTE PROTECTING TIMBERS

compression but weak under tension; steel is satisfactory in both respects. Concrete is durable and little affected by atmospheric influences; steel is subject to corrosion. Reinforced concrete combines the qualities in such a manner as to eliminate to a considerable extent the undesirable qualities and exhibit the desirable prop-

erties. For example, the concrete structure is increased in tensile strength by steel reinforcing bars, while corrosion of the steel is prevented by the concrete coating.

The following methods of reinforcement are employed: (a) Wire netting, expanded metal, and similar meshwork with or without bars; (b) flat bars, special bars, steel joists, etc.; (c) round bars of varying diameter. All of these are suitable for either unit or monolithic method of construction and may be used either singly or in combination. Jointing the steel rods may be done by a long overlap; overlapping and welding; a short overlap with hooked ends; welding; turnbuckles or other mechanical attachment.

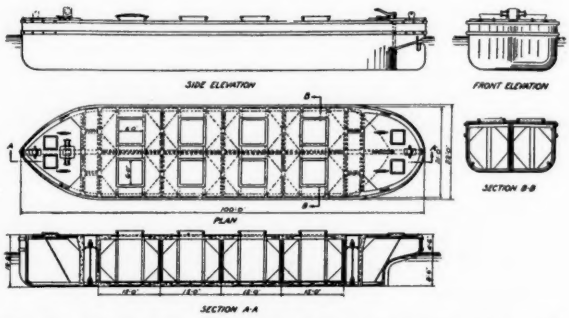


FIG. 4. DIAGRAMS OF REINFORCED CONCRETE COAL AND GRAIN BARGE DESIGNED BY LORD CONSTRUCTION CO.

Casting reinforced concrete vessels may be done by one of two methods: Constructing in one operation, known as the monolithic method, or casting the integral parts separately and assembling them at the slip—the sectional method. This latter method, although suggested, has not been utilized as yet in any construction.

Repairing of local damage, it is thought, presents relatively simple problems. As soon as sufficient concrete and steel in the area of the damage has been removed to allow of an adequate scarf between old undamaged and new reinforcement, fresh concrete and additional rods can be placed. Since concrete sets under water it is not necessary to retain the vessel in dry dock during the initial stages of hardening. The actual time for weathering will depend upon the structural importance and extent of the damaged portion, and unless this is considerable the vessel can return to service after a much shorter lapse of time than was necessary between launching and delivery.

Launching

Launching a vessel subjects the structure to local stresses which may be of considerable magnitude. The process of maturing concrete extends over a period of years, but the increase in strength is very rapid during the early part of that period.

Constructing a vessel in such a situation that she will be water-borne without subjecting her to the severe stresses of launching will decrease materially the delay between the completion of pouring and floating.

Three methods of launching reinforced concrete ships are employed. Two of these, the end and side methods, do not differ from those employed in launching steel or wooden vessels. The third, however, has been conceived in Norway and employed upon no other type of vessel. It consists of letting the ship go into the water bottom up and allowing it to right itself, which it does in 15 to 20 min. The diagram A, Fig. 6, represents a section of the vessel immediately on taking water. The inner mold is divided into compartments and by means of vent pipes air escapes, allowing water to enter, as shown in diagram B. In this position the center of gravity is above the center of buoyancy, giving unstable equilibrium which tends to right the vessel if for any cause the vessel heels to one side or the other. Diagrams C, D and E represent further positions assumed. After the vessel has come to the position E, the flooded compartments are pumped out and the mold is removed.

The Faith

Because the steamship Faith is the forerunner of a new fleet of ships at a time when the nation's need for vessels for this service is greatest, the interest of the country in its launching and its initial trip, which is scheduled to start very soon, has been greatly aroused. To give readers something more than a general idea of the size and equipment of the ship, the following dimensions and description of power plant machinery is given:

The general dimensions are as follows:

Length between perpendiculars	320 ft.
Length over all	336 ft. 6 in.
Breadth, molded	44 ft. 6 in.
Depth to main deck	30 ft.
Depth to lower deck	21 ft.
Deadrise	9 in.
Designed load draft	24 ft.
Dead weight carrying capacity at above draft	5000 tons
Horsepower	1750
Speed	10 knots

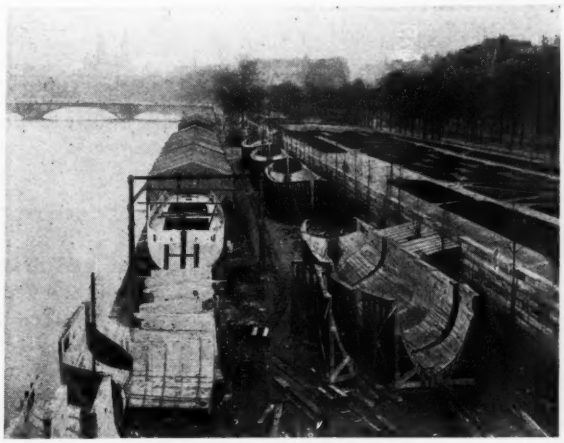


FIG. 5. SHIPYARD IN FRANCE SHOWING CONCRETE BOATS UNDER CONSTRUCTION AND SECTIONAL MOLDS EMPLOYED

The hull is divided into nine water-tight compartments by eight transverse bulkheads of reinforced concrete. The upper deck is of reinforced concrete, while there is a lower deck made of wood. Fuel oil tanks are located in the hold, one forward of the engine room bulkhead and one aft of the collision bulkhead. These are made of reinforced concrete. The engine and boiler casing in the 'tween decks is also of reinforced concrete.

Propulsion will be accomplished by a single cast-iron screw of the four-bladed solid type about 14 ft. 7 in. in diameter driven by a triple-expansion, surface-condensing engine with cylinders 24, 39 and 65 in. by 42 in. supplied with steam from two three-furnace, single-ended Scotch boilers, each 14 ft. 6 in. diameter by 12 ft. 9¼ in. long. The high and intermediate pressure cylinders are fitted with piston valves, while a double ported slide valve is used for the low-pressure cylinder. The valves are operated through a Stephenson link motion with double bar links.

The condenser is separate from the engine framing and has a surface of 2000 sq. ft. The air pump, two boiler feed pumps and two bilge pumps are driven by a duplex pump beam from the low-pressure crosshead of the main engine. The circulating pump is of the centrifugal type direct connected to a vertical steam engine.

The pumping equipment consists of:

One double-acting duplex ballast pump and one double-acting feed pump, each supplied with chamber, bucket, valve seats and rods of brass, ballast donkey valves of india rubber, and those of feed donkey of brass.

The duplex ballast pump is 12 by 8¼ by 12 in. and draws from the sea, bilges and ballast tanks and discharges into condenser ballast tanks, fire main, overboard and to sanitary line.

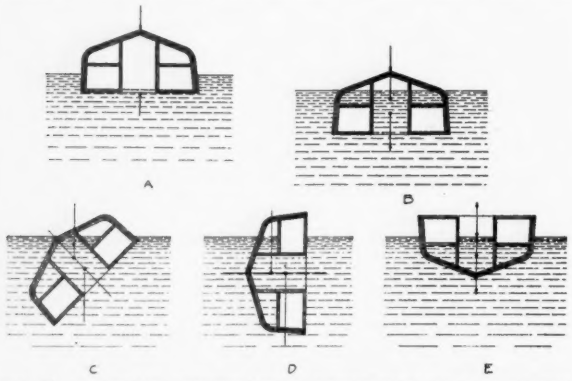


FIG. 6. DIAGRAM ILLUSTRATING PRINCIPLES OF LAUNCHING BOATS, BOTTOM UP, AS PRACTICED AT PORSGRUND, NORWAY

Duplex feed pump is 10 by 6 by 12 in. and draws from condenser, fresh water tanks, from sea and from boilers, and discharges overboard, to feed heaters, to boilers, auxiliary line to donkey boiler and to fresh water tanks.

One duplex oil trimming pump, 6 by 5¾ by 6 in., draws from the main oil fuel tanks and delivers to settling tanks in the engine room.

Two duplex fuel oil pumps 5¼ by 3½ by 5 in. draw from settling tanks and deliver to fuel oil heaters and boilers.

The Faith is equipped with an electric lighting plant, refrigerating plant, steam heating system and steam steering gear.

Data presented in this article has been gathered from a number of sources, including articles in the Journal of the A. S. M. E., International Marine Engineering and Engineering (London), papers and discussions presented at a meeting of the Institute of Naval Architects and bulletins of the Portland Cement Association.

Dimension

THE MANUSCRIPT of the above article was submitted to J. E. Freeman of the Portland Cement Assn. and his comments have such an important bearing upon the subject that they are printed in full below:

"I have read with a great deal of interest your paper on concrete ships and believe that you have covered the subject as a whole very well. There are one or two points, however, on which I would like to mention a word or two here.

"I learn from an article in a recent issue of Concrete and Constructional Engineering (London), that the Zeemeuw has been frozen up in the ice each winter, which makes the service even more interesting.

"In regard to the summation of disadvantages, the excess weight of a concrete ship over a steel vessel is roughly around 20 per cent of total displacement. The Faith has a displacement of only 600 tons greater (7900 to 7300) which amounts to about 8.5 per cent. In the case of wood vessels a concrete ship may be the same or even lighter in weight.

"The extra weight of hull is not of such importance as might appear, for when bulk cargo is carried the concrete ship will carry the same tonnage in cases where the amount of cargo to be carried is measured by space available without reaching maximum weight capacity.

"Greater displacement is offset by lessened skin friction. I do not understand just what item (b) refers to, but if decrease in tonnage is mean, this is covered in preceding paragraphs.

"The cost of building and launching ways is far less than for wood or steel and plant equipment much smaller. The plant, ways, etc., for the Faith cost less than $25,000, while a steel ship yard would have cost ten times that amount. The mechanical equipment was a concrete mixer, hoisting drum, probably a circular saw and a pump, all operated by electricity. Hardly expensive machinery.

" (d) It is pretty generally agreed that repairs can be made more cheaply and readily in concrete than in other ships because of the simpler construction and the elimination of specially punched and fabricated parts to replace damaged sections. As yet our experience has not extended much beyond barges, but there are many instances of easy and successful repair work on such craft.

"The paper by T. W. Gueritte, a French engineer in the April issue of Motorship, brings out several interesting points, and he rather takes the opposite view from the Inst. of N. A. as to the construction of large ships after the present crisis. I believe concrete vessels can be made structurally stronger than any other, and if that is the case it will remain a permanent shipbuilding material for large craft as well as smaller. The amount of steel required is about 50 per cent of that in a steel vessel. That for the Faith was 550 tons.

"I do not feel that the term 'pouring' expresses the exact quality of concrete used in concrete ships. It is not a sloppy-wet but a plastic mix, and as such is deposited by puddling or vibrating forms rather than 'poured.' A plastic concrete has far greater strength than a poured concrete."

Entropy

WHAT IT IS AND HOW TO USE IT IN EVERY-DAY WORK ABOUT THE ENGINE ROOM. BY C. A. JOERGER

WHAT is entropy? What good are the entropy columns in the steam tables? These questions are frequently asked by men having something to do with steam engines and motors. Many have a vague notion that it is purely imaginary, difficult to use and only talked about by men of exceptional ability. There is no reason why anybody who is at all familiar with steam or gas engineering should not be able intelligently to use these entropy quantities.

When an engine is to be built, a drawing is made of it. By means of a drawing, a clearer conception is gotten of it than if one were to attempt to describe it in

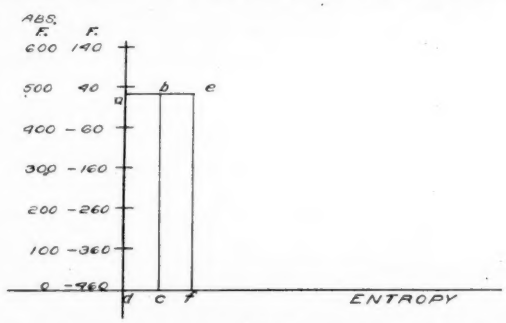


FIG. 1. DIAGRAM TO REPRESENT RELATIONS OF TEMPERATURE, ENTROPY AND HEAT CONTENT OF WATER

words. That is true in all work; a sketch, drawing or picture will generally convey a clearer, quicker and more definite conception of a thing than words. Therefore do the same thing with steam or any gases; that is, draw a picture of its properties and behavior. To do this, it is desirable to have a clear conception of the absolute scale of temperatures.

It was shown by experiment that a gas such as air, hydrogen or any of the so-called perfect gases would expand 0.366 of its volume at 32 deg. F. on heating it from 32 to 212 deg. F. at constant pressure. It was further found that for each degree increase there was the same definite increase in volume; namely,

$$\frac{366}{1000} \times \frac{1}{180} = \frac{1}{492}$$

Similarly, the gas would contract $\frac{1}{492}$ of its volume at 32 deg. F. for each degree drop. If the law continued to hold good indefinitely, the gas would disappear entirely. When the temperature was lowered 492 deg. F. below freezing, which corresponds to — 460 deg. F. It is the point at which the volume would disappear and all the heat would have been abstracted if the gases obeyed indefinitely the laws they do at ordinary temperatures and pressures. Of course, before any gas arrives at this low temperature it changes its physical form, appearing as a solid or liquid. This so-called absolute zero is, however, a very convenient reference point, a sort of bench mark. It is best for the subject under discussion to regard it as the temperature of zero heat content for gases and liquids.

If we take a pound of water and raise its temperature from 32 to 33 deg. F., it takes one B.t.u., assuming the specific heat of water one and constant. Or, to state it a little differently, the heat in the water at 33 deg. F. above 32 deg. F. is one B.t.u. To draw a picture of this, let the ordinates in Fig. 1 represent temperatures and the areas heat, then the heat required to raise water from a to b (32 to 33 deg. F. or 492 to 493 deg. absolute) is represented by area a-b-c-d; the average height of this area is 492.5, therefore the base d-c is equal to $\frac{1}{492.5}$, since the area a b c d represents 1 B.t.u., this is equal to 0.002,03, and can be laid off to any scale of units of length. This number can be found in the steam tables under entropy of the water at 33 deg. F. The value of this line d c is the quantity called entropy. In the same way, in going from 33 to 34 deg. F., area b e f c represents one B.t.u. and c f $= \frac{1}{493.5} = 0.002,03$ and the total length of the base line d to f = 0.0041, which number can be found in the steam tables under entropy of the water at 34 deg.

Taking smaller temperature intervals, a smooth curve is gotten, A B, Fig. 2, the area A K L P at some point K representing the heat in the water at temperature K

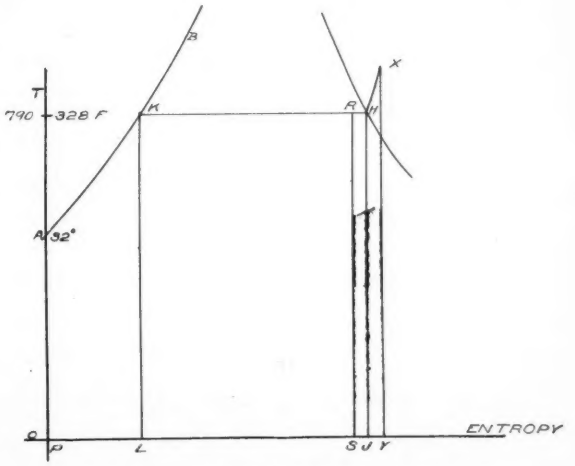


FIG. 2. TEMPERATURE-ENTROPY DIAGRAM

(328 deg. F.) above 32 deg. F. The length of line P L (in any units of length) can be found in the steam tables under entropy of the water at 328 deg. F. equal to 0.4743.

K is the boiling point for water at 100 lb. per square inch absolute pressure, about 85 lb. gage. Evaporating completely the pound of water requires 888 B.t.u. represented by area K H J L; the base L J is found in the steam tables under entropy of evaporation and is, of

course, equal to $\frac{888}{790} = 1.127$; 790 is the absolute temperature corresponding to 328 deg. F. The total heat in a pound of dry saturated steam above 32 deg. F. is represented by the area A K H J P. The line P J is equal to 1.602, the total entropy of dry steam at 100 lb. absolute, which is also listed in the steam tables.

If the steam were 96 per cent dry, the heat added after the boiling point is reached to evaporate only 96 per cent of the water is represented by area K R S L such that K R S L = 0.96 × K H J L. Then L S = 0.96 L J. The total heat for the wet steam is therefore represented by area A K R S P.

If the steam were superheated 100 deg. the temperature would rise to some point X and area H X Y J would represent the heat required to superheat the steam. The total distance P Y can be found in the steam tables under total entropy for superheated steam and is in this case 1.666. The total heat in a pound of steam under this condition is represented by area A K H X Y P.

To appreciate the value and use of this temperature entropy diagram, let an actual condition be assumed.

Figure 3 is an indicator card of a 12 by 12-in. single-valve simple engine. The clearance is 10 per cent, the r.p.m. 302, the steam pressure 124 lb. per sq. in. gage, equals 139 lb. absolute. The quality of the steam is 97 per cent dry. The steam used per hour by actual measurement is 3954 lb.

From the foregoing condition, the cylinder volume is equal to 0.785 cu. ft., clearance volume 0.079 cu. ft., total volume 0.864 cu. ft. The weight of steam per stroke is $\frac{3954}{2 \times 302 \times 60} = 0.109$ lb. The weight of clearance volume steam is equal to 0.011 lb. The total weight of steam per stroke is 0.12 lb.

Mark off a series of points on the indicator card, putting them closer where the changes take place. Then the table can be filled out.

Point on the Card	Absolute Press. lb. per sq. in.	Temp. Deg. F.	Volume to the point on the Card	Sp. Vol. at Press. in 2	Volume of Actual Steam	Quality of Steam X	Entropy of Evaporation F	XF	Entropy of Water	Total Entropy
1	134	350	.0785	3.354	.653	.195	1.075	.209	.503	.712
2	130	347	.1745	3.45	1.45	.420	1.081	.454	.500	.954
3	122	343	.3050	3.67	2.54	.682	1.092	.743	.494	1.237
4	116	339	.343	3.85	2.86	.716	1.101	.789	.489	1.278
5	94	323	.396	4.69	3.32	.708	1.139	.806	.468	1.274
6	66	299	.602	6.56	5.01	.763	1.200	.916	.436	1.352
7	52	284	.785	8.20	6.53	.797	1.240	.988	.415	1.403
8	47	277	.828	9.02	6.84	.760	1.257	.955	.406	1.361
9	39	266	.842	10.74	7.01	.653	1.288	.842	.390	1.232
10	25	240	.863	16.30	7.18	.430	1.360	.585	.353	.938
11	17	219	.828	23.38	6.89	.295	1.422	.483	.323	.806
12	17	219	.654	23.38	5.44	.233	1.422	.232	.323	.555
13	17	219	.441	23.38	3.67	.157	1.422	.223	.323	.546
14	17	219	.314	23.38	2.91	.124	1.422	.176	.323	.499
15	20	228	.243	20.08	2.02	.101	1.397	.140	.336	.476
16	28	246	.194	14.67	1.22	.083	1.343	.112	.362	.474
17	55	287	.109	7.78	.907	.117	1.231	.144	.420	.564
18	80	312	.0785	5.47	.653	.119	1.167	.138	.454	.592
19	106	332	.0785	4.19	.653	.156	1.167	.174	.480	.654

Columns 1 and 2 are self-explanatory. Column 3 is from the steam-tables. Column 4 is obtained from measuring the indicator card. For example, taking point 5 the distance from the zero volume line is 1.84 in., the length of the card is 3.6 in. and represents 0.785 cu. ft., therefore $\frac{1.84}{3.6} \times 0.785 = 0.396$ cu. ft., the volume the steam occupies when piston is at 5. Column 5 is from the steam tables, being the cubic feet per pound of dry steam at the pressures corresponding to the points on the card. Column 6 is obtained by dividing the volumes in column 4 by 0.12, the total weight of steam per stroke, the result is the volume the mixture of steam and water would occupy per pound. Column 7 is 6 divided by 5.

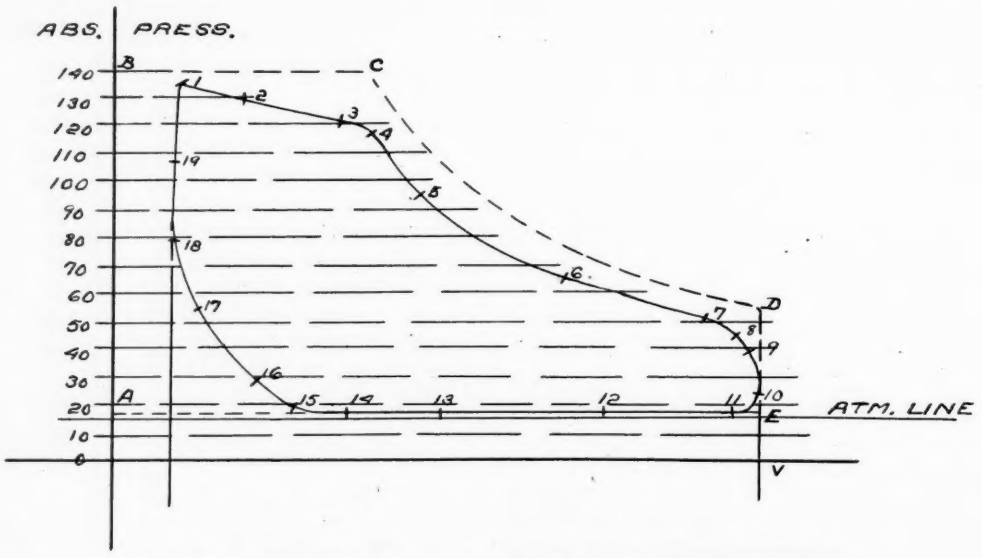


FIG. 3. INDICATOR CARD WITH RANKIN CARD PLOTTED AROUND IT

Column 8 is from the steam-table. Column 9 is the product of 7 and 8. Column 10 is from the steam-table and column 11 is the sum of 9 and 10.

Plot next the results of columns 3 and 11, choosing any convenient scale for temperatures and entropy, Fig. 4. The water line F B and the steam line C E′

are drawn from data in the steam tables. The diagrams show the behavior of a pound of steam.

Plot next the ideal (Rankine) card. This card assumes that the steam reaches cutoff under steam supply conditions, then it expands adiabatically to the end of the stroke, then constant volume reduction in pressure to the back pressure, then constant pressure exhaust to end of stroke without compression. This diagram is represented by A B C D E on the P V diagram, Fig. 3, and also on the T N diagram. The T N diagram is obtained just as the real card was, that is diagram 1 2 3 4 5 — 19.

The value of the diagram is as follows: The total heat supplied is represented by area F B C Z O. The total heat going out the exhaust and thrown out is represented by the area F A E D Z O.

The heat recovered from the exhaust to heat the feed is represented by area F A X O.

The work done (ideal card) is represented by area B C D E A.

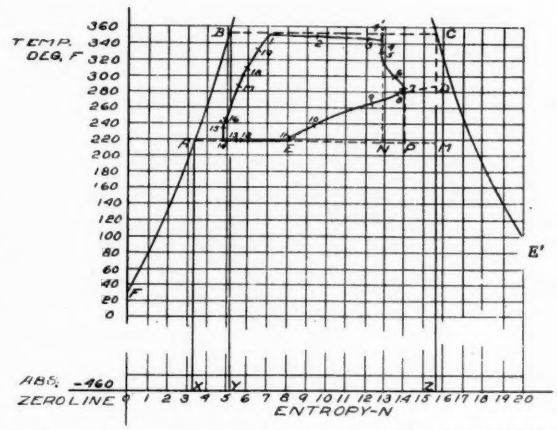


FIG. 4. TEMPERATURE-ENTROPY DIAGRAM OF AN INDICATOR CARD

The net heat supplied per pound of steam is A B C Z X.

The ideal efficiency is

$$\frac{\text{heat supplied} - \text{heat rejected}}{\text{net heat supplied}} =$$

Areas

$$\frac{\text{A B C Z X} - \text{A E D Z X}}{\text{A B C Z X}} = \frac{\text{A B C D E}}{\text{A B C Z X}}$$

This represents the ideal efficiency, the best possible under the conditions. The actual card shows that the heat supplied minus the heat rejected is figure 1-2-3-4-5-6-7-8—19, and it represents the work done. Therefore since the latter area is much smaller than the former, losses must have taken place.

1-4-4′ is a loss charged to wiredrawing; 4-5 shows heat lost to the cylinder walls, a small quantity in this case; 5-6-7 shows re-evaporation, that is heat taken from the cylinder walls. The area under the curves to the absolute zero line represents the heat interchange; C M N 4′ represents the loss due to initial condensation; 7-10-11-P is loss due to incomplete expansion for the actual card; and D E M for the ideal card. From 14-19 shows a gain in heat; but due to the assumptions made, no reliance can be placed upon it.

The assumptions made are that the total weight of steam remained the same throughout the cycle, and that the quality of this steam for any point may be found by comparing the volume which it occupies with that which it should occupy at the same pressure if it were dry and saturated. The evaporation and condensing processes are assumed to take place in the cylinder. The results are therefore only approximate, but one must remember that accuracy in engineering may mean within 20 per cent. The successful man is the one with a large fund of "common sense."

Big Guns

IN today's battles the big guns and the bayonet are the deciding weapons. Machine gun and rifle fire is useful, but is only supplementary to the big fellow and the hand to hand struggle which saves or carries the trench.

It is interesting, therefore, to have a definite idea of the various types and sizes of the artillery. This is classed as guns, Howitzers and mortars; the first being for long range work, the second for medium range and high angle, and the third for short ranges.

Guns have a long barrel, 30 to 50 calibers, high muzzle velocity and range of 6000 to 30,000 yd. They are mounted on wheels for ordinary firing, on trucks for anti-aircraft work, on emplacements for permanent fortifications and on railway bases for use along railway lines. The wheel mounts or mobile artillery are subdivided into pack mounts, which can be taken from and transported on pack mules for mountain work; field guns, attached to rumbles drawn by teams of mules or horses; motorized mounts, drawn by ammunition trucks; tractor mounts, drawn by high power tractors, frequently of caterpillar type, and horse artillery for fast field work with cavalry.

In sizes, guns include the French 75 m.m. or 3-in. and the 4.7-in. for field work; the 5-in. and 6-in. for coast defense, now frequently used on improvised carriages as mobile artillery; the railway guns of 8 to 14 in. caliber. Anti-aircraft guns are in 3 and 4.7-in. bores. Howitzers have a length 18 times the bore and a range of 10,000 to 23,000 yd. at high angle fire. They are mostly used as semi-mobile, being taken down for transportation, and set up where wanted. In size they run from 6.1 to 16 in. bore, the smaller sizes for field work, the larger for bombarding permanent fortifications. They are cheaper than the long, rifled guns and have longer life, but are not as accurate.

Mortars have a length of 10 calibers and a range of 2500 to 15,000 yd. They fire at a very high angle of elevation, and the size most frequently used is about 5-in. bore.

Ammunition used includes shrapnel, which is a casing loaded with bullets about the size of a grape and timed to explode above the enemy line; high explosive shells, gas shells and anti-aircraft shells, weighing from 12 to 1700 lb. each and costing from $10 to $125 exclusive of the cost of explosive and loading.

Zone System of Coal Distribution

LOCATION OF COAL FIELDS, ANALYSES OF COALS FROM VARIOUS MINES AND GOVERNMENT CONTROLLED PRICES

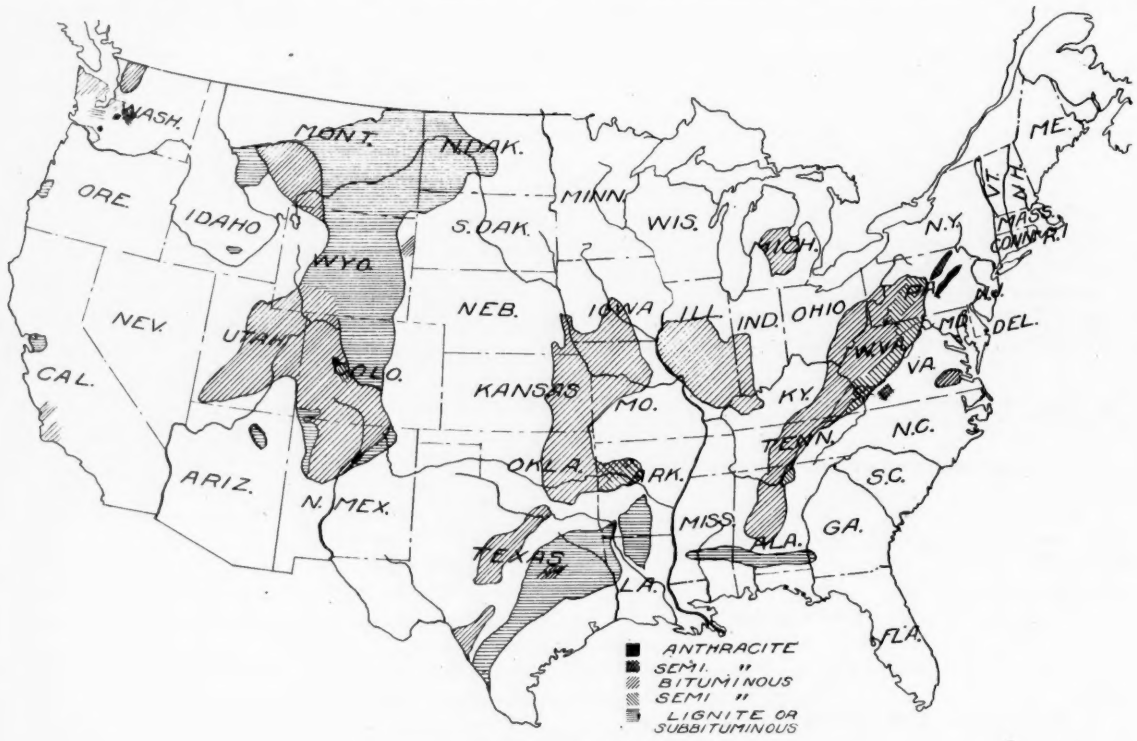
AT no time in the history of the country has the fuel transportation problem failed so completely of solution as during the past year. There has been, of course, a combination of causes for the conditions encountered; but, without question, the situation will be greatly relieved by the zone system which was put into effect on April 1 by the United States Fuel Administration in cooperation with the Director General of Railroads. This system governs the distribution of bituminous coals from the mining districts to the consuming territory along the available transportation routes, and will, as far as possible, avoid congestion at important railway centers, give short hauls from mine to consumer and provide for each territory coal enough for its needs, giving in most cases a choice of coal from two or three different fields.

Such a system of restricting distribution will undoubtedly work hardship or at least an inconvenience upon many power plants that have been designed for a grade of coal that is not now available. Cities having ordinances against smoke will need to be somewhat lenient with power plant owners until furnaces can be redesigned to burn the kind of fuel available, and under the most favorable conditions this would take considerable time.

From an economical standpoint, the zone system will, in the long run, prove an advantage, for the price of coal will be less than that shipped long distances and even the lowest grade of fuel can be burned economically in a furnace designed for its use. Once power plants are equipped to burn the fuel mined closest at hand there is little likelihood of their returning to the former practice of trying to get the highest grade of coal in the country, regardless of the distance it must be hauled.

To aid those who are compelled to change their grade of coal, the accompanying map has been prepared from data published in Government bulletins. As far as possible, analyses of coal from important mines of the country are given in the table which should be of considerable aid in making a selection of coal from the mines in the zone where the plant is located.

In the column headed grade, the coals are divided into the following arbitrary classification: Anthracite, semianthracite, semibituminous, bituminous, subbituminous and lignite.



COAL MAP OF THE UNITED STATES

Anthracite coal may be generally defined as a hard coal having a fuel ratio (fixed carbon divided by volatile matter) of not less than 10. Most of this coal comes from the anthracite fields of eastern Pennsylvania, but small areas are known to exist in Colorado, New Mexico and Washington. The better grades of anthracite coal are today used but little in power plants, due to the high price and the demand for residence heating. Much of this coal that was considered refuse in former days is now being worked over and used for steaming purposes, some burned by itself on specially designed grates,

TABLE I. ANALYSES OF COALS FROM VARIOUS LOCALITIES IN THE UNITED STATES AND ALASKA

State, County and Town	Commercial Name of Coal or Mine	Grade	Proximate Analyses—Dry Coal: Volatile Matter Per Cent	Fixed Carbon Per Cent	Ash Per Cent	Heat Value in B.t.u. per lb. as received
ALABAMA						
Bibb Co.						
Blockton	Blocton Cahaba	Bit.	36.52	57.66	5.82	13,852
Blockton	Old Tennessee Blocton Cahaba	Bit.	37.55	56.58	5.87	17,711
Garnsey	Garnsey	Bit.	32.53	55.46	12.01	12,842
Marvel	Marvel Washed	Bit.	34.20	55.05	10.75	12,919
Jefferson Co.						
Blossburg	Blossburg Pratt	Bit.	29.67	62.15	8.18	13,976
Docena	Old Pratt	Bit.	30.00	63.15	6.85	14,320
Palos	Pratt (Palos Grade)	Bit.	28.95	61.39	9.66	13,382
Pinson	Imperial	Bit.	31.90	61.39	6.71	13,911
Pratt City	Old Tennessee Pratt	Bit.	30.24	62.26	7.50	14,053
Pratt City and Edgewater	Pratt	Bit.	29.78	64.31	5.91	14,299
Warrior	Sibley's Black Creek	Bit.	30.73	63.15	6.12	14,076
Warrior and ElVista	Warrior Black Creek	Bit.	30.51	58.99	10.50	13,333
Wylem	Old Pratt	Bit.	30.40	63.77	5.83	14,430
Wylem	Pratt Strain Lump	Bit.	28.26	64.07	7.67	14,197
Wylem	Pratt	Bit.	30.10	58.60	11.30	13,222
Shelby Co.						
Acton	Acton	Bit.	35.53	56.87	7.60	13,288
Tuscaloosa Co.						
Rock Castle	Jagger	Bit.	28.24	61.86	9.90	13,660
Walker Co.						
Corona	Corona	Bit.	39.27	52.23	8.50	13,197
Sipsey	Sipsey	Bit.	35.86	58.68	5.45	17,723
Townley	Carbon Hill	Bit.	33.78	53.55	12.67	12,146
ALASKA						
Alaska Peninsula						
Chignik Bay	Hook Bay Mine	Bit.	27.24	42.42	25.27	.....
Bering River						
Carbon Creek	Carbon Creek	Semibit.	13.37	78.80	3.61	.....
Carbon Mountain	Carbon Mountain	Anth.	5.01	73.87	7.23	12,137
Carbon Mountain	West Slope	Semianth.	9.82	76.31	6.23	13,059
Carbon Mountain	Outcrops	Anth.	6.76	81.47	5.84	.....
Clear Creek	Tunnel Near Falls	Semibit.	8.75	80.89	4.65	14,186
Kushtaka Ridge	Tunnel on East Face	Semibit.	11.06	73.31	12.95	.....
Cook Inlet						
Port Graham	North Shore Outcrop	Lignite	38.73	32.46	8.85	8,753
Matanuska						
Young Creek	West Bank Outcrop	Bit.	28.32	58.82	10.36	13,093
ARKANSAS						
Franklin Co.						
Denning	Denning	Semibit.	14.74	75.00	10.26	13,644
Sebastian Co.						
Midland	Backe-Denman	Semibit.	17.80	72.37	9.83	13,487
ARKANSAS and OKLAHOMA						
Sebastian and Le Flore Co's.						
Hackett, Huntington and Witteville	Hackett-Huntington	Semibit.	24.62	60.30	15.08	12,863
COLORADO						
Gunnison Co.						
Crested Butte	Ruby	Anth.	4.85	78.57	16.58	11,826
Crested Butte	Horace Mine	Anth.	7.42	82.33	10.25	13,508
Las Animas Co.						
Aguilar	Royal	Bit.	36.02	50.24	13.74	12,672
Beacon	Green Canon	Bit.	36.90	52.00	11.10	12,856
Primero	Primero	Bit.	30.91	56.03	13.06	13,081
Rugby	Primrose	Bit.	36.65	53.48	9.87	12,858
Mesa Co.						
Grand Junction	Book Cliff	Bit.	36.38	53.42	10.20	11,785
Routt Co.						
Oak Creek	Pinnacle	Bit.	40.07	54.39	5.54	12,195
Oak Creek	Yampa Valley	Bit.	41.08	52.84	6.08	12,125
Weld Co.						
Firestone	Russell	Subbit.	40.45	53.30	6.25	9,445
GEORGIA						
Walker Co.						
Pittsburg	Durham	Semibit.	20.33	73.89	5.78	14,364
ILLINOIS						
Bond Co.						
Pocahontas		Bit.	39.16	47.65	13.19	10,951
Christian Co.						
Pana		Bit.	36.82	51.33	11.85	11,907
Clinton Co.						
Breese	Breese	Bit.	41.14	45.50	13.36	10,916
Franklin Co.						
Christopher	Purity	Bit.	36.29	53.58	10.13	12,049
Christopher	Brighton	Bit.	35.75	55.05	9.20	12,081
Macoupin Co.						
Mount Olive	Mount Olive	Bit.	43.23	44.93	11.84	10,925
Staunton	Staunton	Bit.	40.30	46.95	12.75	10,889
Madison Co.						
Collinsville	Cantine	Bit.	42.56	43.59	13.85	10,890
Peoria Co.						
Bartlett	Empire	Bit.	37.70	45.16	17.14	10,426
Erry Co.						
Duquoin	Majestic	Bit.	36.37	50.57	13.06	11,387
Duquoin	Paradise	Bit.	35.48	49.82	14.70	10,903
Duquoin	Queen	Bit.	37.92	50.99	11.09	11,546
Duquoin	Security	Bit.	37.87	51.04	11.09	11,400
St. Clair Co.						
Belleview	Prairie	Bit.	40.91	44.81	14.28	11,034
East St. Louis	O'Fallon	Bit.	43.30	43.15	13.55	11,138
Saline Co.						
Eldorado	Eldorado	Bit.	36.50	53.83	9.67	12,257
Harrisburg	Premium	Bit.	37.91	50.39	11.70	12,148
New Harrisburg	Harrisburg	Bit.	37.20	53.49	9.31	12,380
Ledford	Premium White Ash	Bit.	37.84	53.12	9.04	12,454
Vermilion Co.						
Danville	Electric	Bit.	39.14	44.67	16.19	10,535
Williamson Co.						
Carterville	Carterville	Bit.	32.05	55.62	12.33	11,803
Centerville	Burr	Bit.	34.94	55.98	9.08	12,216
Johnson City	Black Brier	Bit.	34.54	55.31	10.15	12,033
Marion	Scranton Big Muddy	Bit.	37.29	50.47	12.24	11,671
INDIANA						
Green Co.						
Jasonville and Midland	Lattas Creek and Gilmore Mines	Bit.	40.90	50.02	9.08	11,536
Vigo Co.						
.....	Vigo	Bit.	40.54	50.91	8.55	11,808
Warwick Co.						
Booneville	John Bull	Bit.	43.15	44.10	12.75	11,181
IOWA						
Monroe Co.						
Avery	Smoky Hollow	Bit.	40.45	38.68	20.87	9,775
KANSAS						
Cherokee Co.						
Mineral	Cherokee	Bit.	33.79	51.71	14.50	12,436
Crawford Co.						
Englevale	Cherokee	Bit.	32.15	50.50	17.35	11,666
Leavenworth Co.						
Leavenworth	Leavenworth	Bit.	40.31	43.40	16.29	10,869
Leavenworth	Home-Riverside	Bit.	41.43	44.89	13.68	11,208
Richardson	Richardson	Bit.	39.84	44.31	15.85	11,149
KENTUCKY						
Bell Co.						
Blanche	Straight Creek	Bit.	37.93	58.09	3.98	14,198
Pineville	Straight Creek Jellico	Bit.	40.18	56.80	3.02	14,271
Rim	Black River Mine	Bit.	36.11	55.01	8.88	12,971
Straight Creek	Straight Creek	Bit.	33.83	54.77	11.40	12,796
Hopkins Co.						
St. Charles	St.Charles Mine	Bit.	.....	.....	13.82	11,458
Muhlenburg Co.						
Drakesboro	Diamond Block	Bit.	43.28	44.20	12.52	11,370
Union Co.						
Sturgis	Tradewater	Bit.	38.36	51.08	10.56	12,744
Webster Co.						
Clay	Caney Creek	Bit.	36.50	52.65	10.85	12,553
Whitney Co.						
Burk Hollow	Burk Hollow	Bit.	36.70	56.13	7.17	13,348
Mountain Ash	Mountain Ash	Bit.	39.08	55.72	5.20	13,888
MARYLAND						
Alleghany Co.						
Eckhart	Washington No. 2	Semibit.	20.32	72.91	6.77	14,259
Frostburg	Georges Creek	Semibit.	18.83	72.36	8.81	13,935
Lonacoming		Semibit.	20.86	70.26	8.88	13,881
Vale Summit	Davis Six-Foot	Semibit.	19.83	71.95	8.22	13,851
Garrett Co.						
Dodson	Dodson-Cumberland	Semibit.	16.60	68.46	14.94	12,958
MICHIGAN						
Saginaw Co.						
Saginaw	Riverside	Bit.	37.08	50.47	12.45	11,458
MISSOURI						
Macon Co.						
Bevier	Bevier	Bit.	36.11	40.43	23.46	9,354
MONTANA						
Carbon Co.						
Bear Creek	Original Bear Creek	Subbit.	38.49	49.09	12.42	10,661
Bear Creek	Peerless Bear Creek	Subbit.	41.30	47.37	11.33	10,766
Washoe	Faultless	Subbit.	41.53	49.06	9.41	11,054
Cascade Co.						
Sand Coulee	Nelson	Bit.	30.21	51.81	17.98	10,541
Sand Coulee	Sand Coulee	Bit.	29.23	52.56	18.21	10,667
Park Co.						
Chimney Rock	Maxey	Bit.	41.89	48.42	9.69	9,956
NEW MEXICO						
Colfax Co.						
Dawson	Dawson	Bit.	36.84	47.83	15.33	12,551
Koehler	Swastika	Bit.	38.52	33.96	7.52	13,769
McKinley Co.						
Allison	Diamond	Subbit.	42.88	47.70	9.42	11,101
Allison	Gallup	Subbit.	46.84	47.52	5.64	11,513
Rio Arriba Co.						
Madrid	Cerillos	Anth.	5.89	82.53	11.58	12,445
NORTH DAKOTA						
Williams Co.						
Williston	U. S. Reclamation Service Mine	Lignite	47.08	42.03	10.89	6,367

TABLE I (CONTINUED) ANALYSES OF COALS

State, County and Town	Commerical Name of Coal or Mine	Grade	Proximate Analyses—Dry Coal: Volatile Matter Per Cent	Fixed Carbon Per Cent	Ash Per Cent	Heat Value in B.t.u. per lb. as received
OHIO						
Athens Co.						
Hocking	Eclipse	Bit.	36.54	55.90	7.56	13,619
Harrison Co.						
Blairmont	Pittsburg No. 8	Bit.	43.4	49.4	7.2	13,266
Hocking Co.						
Longstreth	Hocking Valley	Bit.	39.69	52.68	7.63	12,608
Jackson Co.						
	Milton Jackson	Bit.			9.61	11,789
OKLAHOMA						
Le Flore Co.						
Bokoshe	Bokoshe	Bit.	16.33	63.98	19.69	11,836
Okmulgee Co.						
Dewar	Dewar	Bit.	34.74	55.96	9.30	12,434
Henryetta	Henryetta	Bit.	37.85	54.47	7.68	12,620
Pittsburg Co.						
Adamson	Adamson	Bit.	36.28	54.99	8.73	13,400
Pittsburg and Latimer Co's.						
	Adamson	Bit.	38.80	51.95	9.25	13,137
PENNSYLVANIA						
Allegheny Co.						
Camden	Camden Mine	Bit.	31.95	56.56	11.49	12,930
Dravosburg	Youghiogheny	Bit.	37.37	55.97	6.66	13,764
Armstrong Co.						
New Bethlehem	Fairmount Mine	Bit.	35.00	53.30	11.70	13,025
Cambria Co.						
Bakerton	Lancashire	Semibit.	22.43	69.31	8.26	13,944
Barnesboro	Delta	Semibit.	21.92	69.66	8.42	13,926
Barnesboro	Empire	Bit.	27.36	63.14	9.50	13,628
Colver	Colver	Semibit.	22.18	70.33	7.49	14,127
Dunlo	Logan	Semibit.	17.83	71.37	10.80	13,470
Elmora	Sterling Mine	Semibit.	19.91	72.29	7.80	14,119
Fallen Timber	Colonial	Bit.	26.01	65.41	8.58	13,920
Hastings	Rick Hill	Bit.	25.51	67.46	7.03	14,119
Johnstown	Bird Quenghoning	Semibit.	16.39	72.81	10.80	13,591
Johnstown	Valley Smokeless	Semibit.	20.14	71.73	8.13	14,165
Johnstown	Morrellville	Semibit.	22.10	68.71	9.19	13,650
Nanty Glo	Cardiff	Semibit.			6.72	14,360
Nanty Glo	Liberty	Semibit.	20.72	71.67	7.61	14,080
Nanty Glo	Borman	Semibit.	20.18	71.58	8.24	13,992
Patton	Beech Creek	Semibit.	20.81	71.87	7.32	14,087
Patton	Pardee	Semibit.	23.26	68.73	8.01	13,887
Portage	South Fork	Semibit.	17.23	75.49	7.28	14,060
Saxman	Greenwich	Bit.	26.37	64.99	8.64	13,788
South Fork	Argyle	Semibit.	17.59	74.63	7.78	14,170
Twin Rocks	Ben Par	Semibit.	19.73	73.40	6.87	14,161
Twin Rocks	Davenport	Semibit.	21.27	72.13	6.60	14,147
Twin Rocks	Star	Semibit.	21.60	71.18	7.22	14,140
Twin Rocks	Big Bend	Semibit.	22.57	70.80	6.63	14,240
Vintondale	Vinton	Semibit.			7.84	14,130
Clearfield Co.						
Hawk Run	Acme	Semibit.	21.01	71.18	7.81	14,140
Irvona	Irvona	Semibit.			9.34	13,898
Ramey	Whitney	Semibit.	22.57	69.43	8.00	13,968
Ramey	Bulah	Semibit.	16.44	78.02	5.54	14,273
Smith Mills	Viola	Semibit.			8.35	13,944
Elk and Jefferson Co's.						
	Shawmut	Bit.	34.15	56.25	9.60	13,210
Fayette Co.						
Braznell	Youghiogheny	Bit.	30.76	58.39	10.85	12,675
Brownsville Jct.	Pike Mine	Bit.	32.16	56.61	11.23	12,937
Huntingdon Co.						
Robertsdale	Rockhill	Semibit.	15.98	75.20	8.82	14,024
Indiana Co.						
Clymer	Empire	Bit.	28.30	62.81	8.89	13,669
Graceton	Graceton	Bit.	25.12	65.50	9.38	13,775
Jefferson Co.						
Delancey and Eleanora	Florence and Eleanora Mines	Bit.	30.72	62.76	6.52	14,040
Eleanora	Adrian and Eleanora Mines	Bit.	31.87	59.02	9.11	17,737
Eleanora	Eleanora Mine	Bit.	32.03	59.54	8.43	13,582
Somerset Co.						
Boswell	Atlantic Mine	Semibit.	17.29	73.51	9.20	13,834
Boswell	Orenda	Semibit.	16.90	73.46	9.64	13,747
Boswell and Jerome	Orenda and Jerome	Semibit.	16.95	72.32	10.73	13,661
Elk Lick	Pine Hill and Elk Lick Mines	Semibit.	20.36	72.93	6.71	14,284
Elk Lick	Merchants, No. 3	Semibit.	16.65	74.57	8.78	13,869
Garrett	Powell	Semibit.	19.40	70.05	10.55	13,468
Hooversville	Knickerbocker	Semibit.	17.21	72.49	10.30	13,651
Hooversville	Margaret	Semibit.	17.24	74.48	8.28	13,811
Jenner	Jenner	Semibit.			9.51	13,884
Jerome	Jerome Mine	Semibit.	15.43	75.89	8.68	13,773
Macdonaldton	Pen Mar	Semibit.	16.17	72.58	11.25	13,398
Zimmerman	Quemahoning Creek	Semibit.	17.49	71.39	11.12	13,469
Washington Co.						
Baird and Hazel Kirk	Youghiogheny	Bit.	36.18	57.12	6.70	13,996
West Brownsville	Pittsburg	Bit.	33.93	57.29	8.78	13,452
Washington and Allegheny Co's.						
Monogahela and Gallatin	Youghiogheny	Bit.	35.69	56.35	7.96	13,657
Westmoreland Co.						
Adamsburg	Youghiogheny	Bit.	34.53	55.68	9.79	13,016
Seward	Ninevah	Semibit.	23.19	69.17	7.64	14,100
Webster	Youghiogheny	Bit.	35.77	56.02	8.21	13,665
TENNESSEE						
Anderson Co.						
Briceville	Cross Mountain	Bit.	36.33	55.25	8.42	13,609
Campbell Co.						
Caryville	Bear Wallow	Bit.	36.37	56.16	7.47	13,671
Claiborne Co.						
Clairfield	King Mountain Mine	Bit.	35.40	50.86	13.74	12,674
Morgan Co.						
Coalfield	Round Mountain	Bit.	37.81	50.80	11.39	13,179
Sequatchie Co.						
Dunlap	Dunlap	Bit.	30.96	58.91	10.13	13,472
TEXAS						
Maverick Co.						
Eagle Pass	Eagle Pass	Bit.	37.73	47.02	15.25	11,323
Webb Co.						
Cannel and San Jose	Cannel	Bit.	42.54	36.88	20.58	10,889
UTAH						
Carbon Co.						
Black Hawk	Black Hawk	Bit.	46.76	46.88	6.36	12,985
Castle Gate	Castle Gate	Bit.	43.50	50.68	5.82	13,048
Hiawatha	Hiawatha	Bit.	45.17	48.96	5.87	12,959
Kenilworth	Aberdeen	Bit.	42.39	51.32	6.29	12,686
Emery Co.						
Mohrland	King	Bit.	45.53	48.21	6.26	13,011
VIRGINIA						
Russell Co.						
Dante	Clinchfield	Bit.	35.50	57.45	7.05	14,073
Russell and Wise Co's.						
Dante and Wilder	Clinchfield	Bit.	36.94	54.41	8.65	13,697
Tazewell Co.						
Pocahontas	Pocahontas	Semibit.	20.93	73.66	5.41	14,479
WASHINGTON						
King Co.						
Black Diamond	Black Diamond	Bit.	40.57	48.18	11.25	11,761
Coal Creek	Newcastle	Subbit.	42.81	43.82	13.37	10,285
Kittitas Co.						
Roslyn	Roslyn	Bit.	37.50	46.07	16.43	12,040
Roslyn	Roslyn Cascade	Bit.	38.24	47.15	14.61	12,297
Roslyn	Roslyn Cascade	Bit.	40.76	45.35	13.89	12,440
Pierce Co.						
Barnett	South Prairie	Bit.	41.07	49.18	9.75	12,978
Carbonado	Carbonado	Bit.	37.87	52.17	9.96	12,914
Wilkeson	Gale Creek	Bit.	36.13	52.48	11.39	13,333
WEST VIRGINIA						
Fayette Co.						
Cannelton	Cannelton Mine	Bit.	34.12	56.28	9.60	13,028
Dubree and Sun	New River	Semibit.			6.31	14,240
Elk Ridge	Kanawha Gas	Bit.	31.57	31.36	7.07	13,849
Elk Ridge, Milburn and Eagle	Cando Gas	Bit.	32.49	59.33	8.18	13,702
Harwood	No. 2 Gas	Bit.	34.29	58.72	6.99	13,811
Layland and Minden	New River	Semibit.	20.74	72.93	6.33	14,026
Long Branch	Long Branch	Bit.	27.43	65.77	6.80	14,067
McDonald and Glen Jean	New River Smokeless	Semibit.	19.90	72.92	7.18	13,902
Milburn	Milburn Gas	Bit.	32.84	60.74	6.42	14,023
Minden	New River	Semibit.	21.86	72.00	6.14	14,162
Prudence	New River	Semibit.	22.84	70.85	6.31	14,351
Red Star	New River	Semibit.	24.53	69.85	5.62	14,431
Smithers	Richwood	Bit.	31.50	59.27	9.23	13,551
Harrison Co.						
Mount Clare	Hutchinson	Bit.	39.53	53.74	6.71	13,963
Wilsonburg	Fairmont	Bit.	42.02	49.90	8.08	13,447
Kanawha Co.						
Acme, Decota and Kayford	Acme Splint	Bit.	33.12	55.89	10.99	13,064
Carbondale	Smithers Creek Gas	Bit.	36.80	57.41	5.79	14,206
Decota	Kanawha No. 2 Gas	Bit.	34.41	56.91	8.68	13,526
Kayford, Leewood and Wevaco	Cabin Creek Gas	Bit.	34.41	56.35	9.24	13,576
Kanawha Co.						
Laing and Giles	Kanawha Gas	Bit.	33.18	59.45	7.37	13,858
Laing	Kanawha No. 2 Gas	Bit.	35.21	56.12	8.67	13,574
Queen Shoals	Queen Shoals	Bit.	33.61	55.44	10.95	13,000
Sharon	Kanawha	Bit.	34.35	53.61	12.04	12,611
McDowell Co.						
Davy	Pocahontas	Semibit.	19.37	73.23	7.40	13,943
Elkhorn	Pocahontas	Semibit.	19.15	74.67	6.18	14,463
Hemphill	Pocahontas	Semibit.	19.01	73.44	5.55	14,136
Jed	Pocahontas	Semibit.	19.16	74.00	6.84	13,702
Jed and Leckie	Pocahontas	Semibit.	17.89	76.51	5.60	14,348
Landgraf	Pocahontas	Semibit.	17.74	75.48	6.78	14,251
Leckie	Pocahontas	Semibit.	19.29	74.10	6.61	14,172
Mayberry	Pocahontas	Semibit.	18.83	73.93	7.24	13,912
Welch	Pocahontas	Semibit.	18.37	73.24	8.39	13,987
Marion Co.						
	Fairmont Gas	Bit.	37.06	54.67	8.27	13,547
Mercer Co.						
Mc Comas	Pocahontas	Semibit.	18.38	74.80	6.82	14,292
Mineral Co.						
Blaine	Blaine	Semibit.	15.92	74.63	9.45	13,748
Keyser	Peerless	Semibit.	16.85	68.89	14.26	12,918
Mingo Co.						
Chattaroy	Buffalo White Ash	Bit.	34.37	52.31	13.32	12,315
Raleigh Co.						
Glen White	New River	Semibit.	19.53	74.08	6.39	14,050
Glen White (near)	New River	Semibit.	17.55	75.34	7.11	14,118
Sprague	New River	Semibit.	21.32	74.38	4.30	14,585
Stanaford	New River	Semibit.	21.11	73.54	5.35	14,532

TABLE I (CONCLUDED) ANALYSES OF COALS

State, County and Town	Commerical Name of Coal or Mine	Grade	Proximate Analyses—Dry Coal: Volatile Matter Per Cent	Fixed Carbon Per Cent	Ash Per Cent	Heat Value in B.t.u. per lb. as received
Randolph Co.						
Weaver	Beaver Creek	Bit	28.77	58.72	12.51	13,030
Tucker Co.						
Albert	Douglas	Semibit	.....	.....	7.51	14,024
Corketon	Davis	Semibit	21.47	70.01	8.52	13,688
Thomas	Thomas	Semibit	17.39	72.47	10.14	13,446
Raleigh and Fayette Co's.						
Various Mines	New River	Semibit	22.09	72.48	5.43	14,390
Various Mines	New River	Semibit	23.06	70.81	6.13	14,246
WYOMING						
Hot Springs Co.						
Gebo	Owl Creek	Subbit	44.19	51.14	4.67	11,157
Lincoln Co.						
Sublet	Kemmerer	Bit	38.19	56.29	5.52	13,418
Sheridan Co.						
Acme	Acme	Subbit	47.91	46.74	5.35	9,559
Carneyville	Carney	Subbit	43.10	52.36	4.54	9,710
Dietz	Sheridan	Subbit	40.45	45.36	14.19	9,095
Kool	Kool	Subbit	52.52	41.88	5.60	9,602
Monarch	Monarch	Subbit	44.20	48.17	7.63	9,506
Sweetwater Co.						
Rock Springs	Star Lump	Bit	43.56	52.55	3.89	12,471

some mixed with bituminous coal and burned on grates, and some in powdered form.

Semianthracite coal has a fuel ratio ranging from 6 or 7 to 10 and may be disregarded as a power plant fuel due to the small amount that is found in the country. It might, however, find some local use in northeastern Pennsylvania, western Arkansas, and parts of Washington.

Semibituminous coal is the best steam coal in the country, but is not widely distributed, the principal fields being in West Virginia, Maryland, Pennsylvania and the western part of Arkansas, although small areas are found in Colorado and Washington. It has a fuel ratio ranging from 3 to 6 or 7. This grade of coal will be recognized under the commercial names of Pocahontas, Georges Creek, New River and Windber. Many of the plants in middle western states that have depended upon this grade of coal to secure smokeless combustion are now compelled to change to another grade owing to the enforcement of the zone system.

Bituminous coal is by far the most important in the country and includes most of the central western coals east of the Rocky Mountains. Vast fields of bituminous coal are found in Colorado, New Mexico, Utah, Wyoming and Washington. This grade runs rather high in volatile ranging from 25 to 40 per cent, and when burning has a long flame. While nearly all coking coals are of the bituminous grade, bituminous coals do not all coke readily and for all purposes they must be selected with great care, as they vary greatly in character.

The grade designated as subbituminous is what has generally been called black lignite. This change in name has been made by the United States Geological Survey for the reason that the coal is not lignitic in the sense that it is woody, and the latter term implies that it is little better than the brown lignite of North Dakota. Subbituminous coal, however, approaches bituminous, and in many cases can hardly be distinguished from it. The distinguishing features between lignite and subbituminous coal are the color and freedom from woody texture in the latter. Subbituminous coal slacks readily when exposed to atmosphere, which distinguishes it from bituminous.

This grade of coal is found in most of the western fields, being well known around Boulder, Denver and North Park, Colo.; Gallup, N. Mex.; Hanna, Douglas, Sheridan and the Big Horn Basin, Wyo.; Red Lodge and Musselshell, Mont.; and in many districts in Washington and Oregon.

Lignite, as the term is used by the Geological Survey, applies to coals that are distinctly brownish in color and generally woody. They are intermediate in quality between subbituminous and peat. Lignite is abundant in North Dakota, eastern Montana and the northwest corner of South Dakota. In the South it is reported to be present in all of the Gulf states, but has been developed commercially only in Texas.

For the Pacific Coast states, the Alaska coal fields represent a source of almost unlimited fuel supply which has as yet been little developed. These fields contain coal of all grades ranging from anthracite to lignite, and are available for ship transportation.

In Table II are given the prices of bituminous coals which the Government allows the operators to charge at the mines. While these are subject to some variation the fluctuation under Government control will not be great and estimates made upon these prices may be considered reliable.

During the past year, considerable complaint has been made about the quality of coal received. Those who used coal from the same mines as formerly, stated that it had depreciated greatly in quality, containing

TABLE II. BITUMINOUS COAL PRICES F. O. B. AT MINES

State	Run of Mine	Prepared Sizes	Slack or Screenings
Alabama:			
Bibb, Steam district	$2.15	$2.45	$1.85
Cahaba, Black Creek, Brookwood and Blue Creek districts	2.85	3.10	2.45
Coal City districts	2.35	2.65	2.05
Pratt, Jaeger, Jefferson, Nickel Plate and Corona district	2.40	2.75	2.05
Montevallo district	2.40	4.00	2.15
Coal mined in upper bench of Big Seam	2.35	2.65	2.05
Coal mined at Lynn mines of Monroe Warrior Coal and Coke Co. for use at Macon, Ga.	3.50	4.00	3.10
Coal mined by Cahaba Southern Coal Mining Co., Hargrove, Bibb County	2.85	3.70	2.45
Climax Seam, near Maylene, Shelby County	4.25	4.50	2.15
Arkansas	2.65	2.90	2.40
Johnson, Franklin and Sebastian Counties, except Excelsior district	3.70	4.60	2.40
Logan and Scott Counties and the Excelsior district of Sebastian County	4.35	5.15	2.60
Colorado	2.45	2.70	2.20
Domestic coal, domestic field*	2.25	3.50	1.25
Steam Coal, Trinidad district†	2.35	3.25	1.65
Lignite coal	2.25	3.25	1.00
Georgia	3.25	3.50	3.20
Illinois:			
Mercer, Bureau, Kankakee, La Salle, Grundy, Will, Putnam, Marshall, Livingston, Woodford, and McLean Counties	2.65	2.90	2.40
Rock Island, Henry, Warren, Knox, Stark, Peoria, Hancock, McDonough, Henderson, Fulton, Tazewell and Schuyler Counties	2.40	2.60	2.10
Menard, Logan, Dewitt, Champaign, Vermilion, Sangamon, Macon, Pratt, Christian, Moultrie, Shelby, Greene, Macoupin and Montgomery Counties, Madison County north of latitude of Alton, and all mines which are not included in other rulings	2.00	2.20	1.70
Bond, St. Clair, Monroe and Randolph Counties and Madison County south of latitude of Alton, and Clinton, Washington and Perry Counties, not including mines along Illinois Central R. R. between Vandalia and Carbondale	2.00	2.20	1.70
Jackson County, not including mines along Illinois Central R. R. between Carbondale and Duquoin	2.40	2.60	2.10
Marion, Jefferson, Franklin, Williamson, Johnson, Hamilton, Saline, White, Gallatin, and mines along main line of Illinois Central between Vandalia and Carbondale			

* Prepared sizes subject to the following monthly reductions in price: May 1, 50c; June 1, 35c; July 1, 15c; base price again effective Aug. 1.

† Prepared sizes subject to following monthly reductions in price: May 1, 30c; June 1, 20c; July 1, 10c; base price again effective Aug. 1.

Table II (Concluded) Coal Prices

State	Run of Mine	Prepared Sizes	Slack or Screenings
in Clinton, Washington, Perry and Jackson Counties	2.00	2.20	1.70
Indiana	1.95	2.20	1.70
Brazil Block field	....	2.95	1.70
Iowa	2.70	2.95	2.45
Appanoose, Wayne, Boone, and Webster Counties	2.75	3.10	2.00
Marion County	2.70	2.95	2.45
Kansas	2.55	2.80	2.30
Cherokee and Crawford Counties, except shaft mines in Lightning Creek or upper thin vein and any mining operations in the state not covered by other rulings	2.70	2.95	2.45
Shaft workings in the Lightning Creek or upper thin vein in Cherokee and Crawford Counties	3.65	3.95	2.45
Osage, Franklin, and Linn Counties	3.50	4.50	2.80
Leavenworth County	3.40	3.65	2.90
Kentucky	1.95	2.20	1.70
Harlan, Perry and Letcher Counties, and operations in Pike County on the Levisa Fork of the Big Sandy River	2.20	2.45	1.95
East of the 85th degree of longitude, except Harlan, Perry and Letcher Counties and operations in Pike County on the Levisa Fork of the Big Sandy River	2.65	2.90	2.40
Thacker district: Operations in Pike County on the watershed of the Tug Fork of the Big Sandy River east of Williamson on the Norfolk & Western Railroad	2.30	2.55	2.05
Kenova district: Operations in Pike County and Martin County on the watershed of the Tug Fork of the Big Sandy River west of Williamson on the Norfolk & Western R. R.	2.30	2.55	2.05
Maryland	2.40	2.65	2.15
Michigan	3.15	3.60	2.20
What Cheer, Banner, Bliss, Robert Gage, Beaver and Consolidated & Wolverine coal companies	3.40	3.95	2.25
Handy Bros.	3.70	4.25	2.55
Caledonia mine	4.55	5.05	3.55
Flint mine	....	5.55	3.55
Missouri	2.70	2.95	2.45
District No. 1: Audrain, Bates, Calloway, Henry, Johnson, Monroe, Randolph, Ralls, St. Clair, Schuyler, Vernon, and Montgomery Counties, Adair County except operations of the Star Coal Co., and Macon County, east of New Cambria and mining operations not covered by other rulings	2.70	2.95	2.45
District No. 2: Boone, Clay, Cooper, Chariton, Carroll, Dade, Harrison, Linn, Lafayette, Putnam, Ray, and Sullivan Counties, and Macon County west of New Cambria and the long wall thin seam mines in Randolph County	3.15	3.40	2.45
Grundy County: Operations of the Star Coal Co., in Adair County and shaft workings in the Lightning Creek or upper thin vein in Barton, Bates, and Vernon Counties	3.65	3.95	2.45
Platte County	3.40	3.65	2.45
Montana	2.65	3.30	1.50
New Mexico	2.40	2.65	2.15
Raton district	2.35	3.25	1.67
Sugarite and Monero field	3.00	4.00	2.00
Gallup field	3.05	4.05	2.00
Cerillos field	4.05	4.55	3.55
Carthage field	4.25	5.05	3.55
North Dakota (lignite):			
Run-of-mine	....	....	2.25
Screenings	....	....	1.25
Screened lump	....	....	2.50
6-in. steam lump	....	....	2.00
Ohio:			
Thick vein	2.00	2.25	1.75
Thin vein	2.35	2.60	2.10
Deerfield, Palmyra, Massillon and Jackson fields	3.25	3.50	3.00
Jefferson, Harrison, Belmont, Carroll and Monroe Counties	2.00	2.25	1.75
Oklahoma	3.05	3.30	2.80
Leflore, Haskell, Okmulgee, Tulsa, Rogers and Coal Counties and the Hartshorn-Wilburton vein in Pittsburgh and Latimer Counties	3.70	4.60	2.40
McAlester vein in Pittsburgh and Latimer Counties	4.25	5.10	3.00
Pennsylvania	2.00	2.25	1.75
Operations in Tioga, Lycoming, Clinton, Center, Huntingdon, Bedford, Cameron, Elk, Clearfield, Cambria, Blair, Somerset, Jefferson, Indiana, Clarion, Armstrong, Butler, Mercer, Lawrence and Beaver Counties, and in Allegheny County from Lower End of Tarentum Borough north to county line, and in Westmoreland County from point opposite lower end of Tarentum Borough north along Allegheny River to Kiskiminitas River and along Kiskiminitas River eastward to Conemaugh River and along Conemaugh River to Cambria County line, and operations on B. & O. R. R., from Somerset County line to and including Indian Creek and Indian Creek Valley branch of B. & O. R. R.	2.60	2.60	....
Pittsburgh field, including counties of Washington, Green, Fayette, Westmoreland and Allegheny, except (1) that portion of Allegheny County from lower end of Tarentum Borough north to county line; (2) territory in Westmoreland County from a point opposite lower end of Tarentum Borough north along Allegheny River to Kiskiminitas River and along Kiskiminitas River eastward to Conemaugh River, continuing along Conemaugh River to county line of Cambria County; (3) operations on Indian Creek in Westmoreland County; (4) operations in the Ohio Pyle district of Fayette County	2.00	2.25	1.75
Ajax Hocking Coal Co., Clearfield and Somerset Counties	2.75	....	....
Tennessee:			
All except Overton and Fentress Counties	2.65	2.90	2.40
Overton and Fentress Counties	2.20	2.45	1.95
Texas	2.65	2.90	2.40
Operators at Thurber and Strawn	3.60	4.40	2.25
Operators at Bridgeport	4.25	5.05	2.25
Young, Erath, and Palo Pinto Counties	3.60	4.40	2.25
Wise County	4.25	5.05	2.25
Lignite run of mine	....	....	1.40
Lignite, screened, with at least 15 per cent of screenings taken out	....	....	1.50
Lignite screenings	....	....	0.85
Utah	2.65	3.30	1.50
Virginia	2.00	2.25	1.75
Lee, Wise and Dickenson Counties, and Russell County west of Finney on the Norfolk & Western Ry.	2.20	2.45	1.95
Washington (Screened Coals):			
Kittitas County	3.55	3.95	2.50
Kittitas County, special steam and gas	....	3.25	....
Lewis and Thurston Counties, sub-bituminous	2.75	....	1.25
Lump	....	3.95	....
Lump nut	....	3.25	....
Nut	....	3.00	....
Washington (Washed Coals):			
Kittitas County	....	4.00	....
Pierce, King, Lewis and Skagit Counties	....	....	2.50
Lump nut	....	6.00	....
Mixed steam	....	5.25	....
Straight steam and gas	....	4.80	....
King County, sub-bituminous	....	....	1.50
Lump nut	....	5.00	....
Pea	....	3.50	....
Buckwheat	....	3.25	....
Lewis County, sub-bituminous	....	....	1.25
Lump	....	3.95	....
Nut	....	3.75	....
Pea	....	3.00	....
Buckwheat	....	1.50	....
West Virginia	2.00	2.25	1.75
Pittsburgh seam in Hancock, Brooke, Ohio, and Marshall Counties	2.00	2.25	1.75
Kenova and Thacker fields and Preston County	2.40	2.65	2.15
Pomeroy field	2.35	2.60	2.10
Davy-Pocahontas Coal Co. in McDowell County	2.75	....	....
Ajax Hocking Coal Co. in Mineral County	2.75	....	....
No. 10 district: Coal and coke and Gauley districts; Taylor, Barbour, Lewis, Buckhannon, Randolph, Gilmer, Braxton, Webster, and Greenbrier Counties; operations in Nicholas County east of the mouth of the Meadow branch of the Gauley River and coal and coke district in Kanawha and Clay Counties north of Charleston	2.30	2.55	2.05
Fairmont district: Monongalia, Marion, and Harrison Counties	2.15	2.40	1.90
Thacker district: Operations in McDowell County west of Panther on the Norfolk & Western and in Mingo County west along the Tug Fork of the Big Sandy River to Williamson on the Norfolk & Western	2.30	2.55	2.05
New River district: Fayette County south of Hawk's Nest on the Chesapeake & Ohio and Fayette and Raleigh Counties south of Paintsville on the Virginian Railroad and Wyoming County north of Herndon on the Virginian Railroad	2.35	2.60	2.10
Logan district: Logan County and operations in Boone County south of Danville on the Chesapeake & Ohio, and Lincoln County south of Gill on the Chesapeake & Ohio Railroad	2.15	2.40	1.90
Putnam County	2.50	2.75	2.25
Kenova district: Operations on the watershed of the Tug Fork of the Big Sandy River west of Williamson on the Norfolk & Western Railroad, and Wayne County	2.30	2.55	2.05
Kanawha district: Nicholas County west of of the mouth of the Meadow Branch of the Gauley River, Fayette County west of Hawk's Nest on the Chesapeake & Ohio Railroad, and north of Paintsville on the Virginian Railroad, and operations in Raleigh and Boone Counties on the watershed of the Clear Fork Branch of Coal River, Boone County, north of Danville on the Chesapeake & Ohio Railroad, Kanawha County south of Charleston, and Lincoln County north of Gill on the Chesapeake & Ohio Railroad	2.25	2.50	2.00
Wyoming	2.65	3.30	1.50

The foregoing prices are f.o.b. mines basis for ton of 2000 lb. and do not include the 45c per ton allowed in President's order of Oct. 27, 1917.

more ash and clinker-forming materials. Such a condition can be laid to a lack of labor at the mines or the growing indifference of the mine operators to preparing their coal properly for the market. Reference to the following table will clearly reveal why coal as mined should be prepared, i.e., hand picked, or washed, or both, depending upon the impurities in the coal bed; any neglect will result in poor quality of coal. The sections of the bed given here are from one of the principal mines in Franklin county, Illinois, and are probably as good as the best in the district.

Section	A		B		C	
Roof, shale	Ft.	In.	Ft.	In.	Ft.	In.
Top Coal[a]	4	0	4	0	..	..
Coal	0	8	0	8	3	2
Blue band[b]	..	..	..	..	0	1
Mother coal and shale	0	1/8	0	1/8	..	..
Coal	0	11	0	11	2	0
Mother coal	..	..	..	..	0	1/2
Shale	0	1/16	..	1/16	..	..
Coal	3	8	3	8	2	0
Blue band	0	1	0	1	0	1/2
Coal	2	6	2	6	3	10
Floor, shale—						
Thickness of bed	11	10 3/16	11	10 3/16	11	2
Thickness of coal sampled	7	10 3/16	7	10 3/16	11	2

[a]Not included in sample.

[b]The blue band was included in sample, as it was loaded with the coal. It burns readily to ash. It is from 1/2 to 1 1/2 in. thick.

In changing from one grade of coal to another, it should be kept in mind that, as a general rule, increase in volatile combustible matter requires an increase in combustion space, particularly in the distance traveled by the gases between the grate and the heating surfaces; also an increase in the amount of air that should be admitted over the fuel bed. Increase in the percentage of ash requires more frequent cleaning, larger openings in grates, stronger draft and greater care in firing to prevent clinker, although the fusing point of the ash is usually the determining feature in the formation of clinker.

Order Brick Early

IN MAKING PLANS for building or remodeling plants, engineers should note that the Fuel Administration has ordered a curtailment of 50 per cent in the manufacture of face brick, common brick, paving brick, terra cotta, roofing tile, floor and wall tile; and of 25 per cent in hollow tile and drain tile. This is done to restrict the building of new factories to that absolutely necessary, and encourage the use of old buildings so far as possible.

The order does not curtail firebrick production, but it is likely that there will be some difficulty in getting deliveries on the grades which have been curtailed, hence orders should be placed well in advance of requirements.

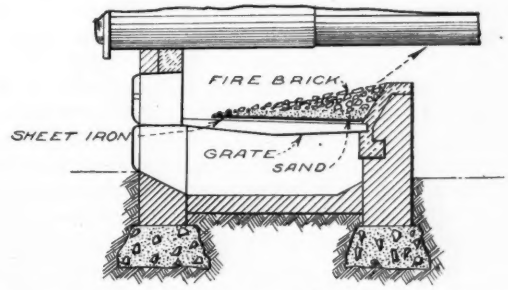
ELECTRIC LIGHT PLANTS for private dwellings are desired by a man in Canada, who will pay cash for the outfits. Further information can be had from the Bureau of Foreign and Domestic Commerce, Washington, D. C., referring to opportunity 26,807.

Our Oil Burning Experience

HOW WE LEARNED BY TRYING, AND OUR FINAL CONCLUSIONS AS TO BURNERS, PRESSURES AND FURNACE. BY JOHN PIERCE

IN writing this article it is not my intention to go into intricate technical questions, but to state plainly my experience with oil burners, and the results obtained by different methods of firing with oil, so that some other engineer with as little education as myself can understand and be benefited by the article. By "results" I mean results in general, and not the one, or perhaps two, days' tests with everything prepared and in perfect shape—but for ordinary every-day practice. I cannot give the recorded figures, either, owing to the fact that this company had a lawsuit two years ago over street lighting; the engine room records were taken to the courts and as yet have not been returned.

In 1908, this plant being pressed for more steam and not being in a position to install more boilers, I purchased a set of oil burners and installed them under the battery of boilers which we had in service. In this little city we had a man who claimed to have been the "father" of the particular burner purchased. In fact, we purchased it through him and of course we expected



DETAIL OF FURNACE ARRANGEMENT FOR OIL BURNING

to get all the fine points of operation from the same source. I knew nothing whatever of oil burners, neither did any of my men. So the said "father" came over and told me how to connect up those burners. According to him I was to put up a 4-in. pipe 40 ft. from bottom to top. Then I should tap a 1/2-in. line from near the bottom of said pipe to the oil side of the burner. Near the top, a 3/4-in. outlet was to carry away the overflow and return it to the tank, another line from pump to standpipe was laid—no heat on oil being required. This was all right—and gave fine results as to economy so long as our load was very light. But when load was heavy enough to demand a fast hot fire we couldn't keep up steam. In firing with this arrangement we covered the grates with old sheet iron, making them airtight from the bridge wall to within 18 in. of the dead plate—over the iron we put 2 in. of sand, and then piled in pieces of fire brick from the top of the bridge wall sloping to a feather edge at the line of sand and sheet iron.

Air was admitted through ash pit doors and fire was sent over the rough pieces of brick in a sheet, striking them at a gentle angle and "flowing" along under the boilers, yet not actually coming into contact with the boilers until reaching the point indicated by arrow; a point 3/4 the distance back. At this point, let me say

that with this arrangement it is almost impossible to "bag" or "blister" a boiler, even though it has a large amount of scale lying along the bottom. However, we found, as I said, that our steaming capacity was not great enough, so we decided that we did not know a great deal about oil burning and said "father" knew less; and I went visiting.

In fact, for over two years the manager and I went, first one for two weeks, then the other for two weeks, stopped, looked and listened to all the oil burning men and plants we could find. We would take notes, watch methods and then go home and try it out on our furnaces. The first thing we learned, or had taught us, rather, was that we should have a pressure of from 50 to 80 lb. on our oil lines, and that it—the oil—should be as hot as it could be made. We then took down our "standpipe" and put up a tank tested at 250 lb. pressure; sent to Chicago and had a coil made from ½-in. pipe containing 100 ft. of pipe which I placed inside of the tank and ran exhaust from the oil pump through it.

This made the oil very hot and also gave the desired pressure. With this arrangement we found, using 65-lb. pressure, that we could keep up any amount of steam needed, to the very limit of the boilers' capacity. When that was reached, we, of course, could do no more as regards making steam, yet we could go on and melt the very breeching off the boilers, and they are return tubulars at that. At times we had to give the furnace a little more air through the fire doors—owing to atmospheric conditions—but usually enough was admitted through the 18-in. opening of the grates. On an ordinary load we could close the ash pit doors almost tight. This let in but little air and our fires filled the entire furnace, not rolling and flowing along as previously described, but eddying and apparently just quivering back and forth, filling the furnace with a pale blue flame of a slight purple cast. It made absolutely no noise or vibration and steamed *most* economically. When load was at its peak and the 16 by 36-in. as well as 12 by 6-in. engines were both loaded, two little old 60-in. by 6-ft. boilers had a lot of work on their hands, so we had to force them. In using this force we had, as I said, to give her more air. Then the blue flames turned into white, edged at the extreme back with red, and would roar and vibrate until it seemed as if the very windows would fall out. When more air was admitted through the furnace doors, flame would take the color of extreme dazzling white. Steam at 100 lb. was used on the burner and regulated according to the amount of oil being fed through the burners. The top of the stack was watched very closely. A trifle too much steam on the burners for the oil carried would result in a light vapor at the top of the stack. If not enough steam was used, light smoke would appear, and more oil and less steam would cause a very black smoke. The amount of air admitted would also make a very small showing at top of stack, but the best way of judging the proper amount of air was through the peep holes by the appearance of the fire. I would say here that practice for a short time teaches one more regarding the appearance of fires and proper regulation than one could explain in a week's writing.

As said before, we kept trying and experimenting for over two years, making very careful tests, measuring and metering our oil, water, etc., and then checking the entire set of measurements with a duplicate set of meters, indicating engines every two hours, day and night, until we finally decided that for everyday service we would get the best results from the "Higgins" burner and from the above described system—except that we later found that we did not need any heat on our oil in order to get the same results. We installed a pump large enough to run very slowly and supply plenty of oil to the burner as well as keep a constant small stream flowing back, through the regulating valve, to the tanks. We also did away with the tank and the heating coil, pumping our oil direct to the burners. We keep a constant pressure of 65 lb. on the oil line and, as before stated, 100 lb. on the steam line. We used a number of different burners and found that all of them were practically the same efficiency as far as the amount of fuel was concerned; but we settled on the Higgins, owing to the fact that with this burner we could burn heavier, dirtier oils than with any of the others tried out. It is not my intention to name any special sort of burner or make with the object of advertising that burner, but merely to show why we decided finally to use it.

In our experiments we tried every possible way which we could learn of and many which we originated. With the system which we adopted we had less soot in the flues than with any other way. In burning oil, as with coal, one should be very careful to keep all cracks stopped up, and the boilers in as good condition as it is possible to have them. We found that having boiler capacity to fire with coal, it was and is much cheaper to use coal, though much cleaner and nicer to use oil; however, I cannot give any accurate results of our tests owing, as I said, to our records being gone. Yet I do remember that we did not evaporate the startling amount of water per pound of oil that some others claimed, and I know that I went personally to see the performance of one or two of these high record plants and found that only under *perfect* conditions for one day at a time could they get such records, and could not maintain them day after day under normal working conditions. We use Diesel engines now, and so do not burn oil any more, this being the reason why I have no records today of our late running conditions. At the price of the oil purchased today, however, I should say that it is 50 per cent cheaper to burn coal if boiler capacity is great enough to furnish the necessary steam.

Eat Potatoes

LAST YEAR a big crop of potatoes was raised, but transportation difficulties during the winter kept them from reaching the market. Now there is a plentiful supply at moderate prices, and it is good sense, good economy and good patriotism to use them and thus save the grains and flours which are scarce. Potato flour is easily used in combination with other flours for making bread, cookies, cakes and puddings. And potatoes can be served in many appetizing forms, reducing the amount of bread used. Some of the present stock of potatoes can be made into flour or dried and carried over to next winter, but most of it should be used and grains saved. Therefore, eat potatoes; save grain; save money.

Steam Turbine Distortion

IN turbines, with their high speeds of rotation, reaching, in the largest units, a velocity of 1000 ft. a second for the low-pressure blades, even a slight amount of distortion, which causes rubbing or unbalancing may result in serious trouble. The distortion is liable to come, in the case of moving parts, from centrifugal force, due to high speed, and in the case of stationary parts, from large temperature changes, due to sudden changes of load and consequently varying pressures, especially in the low pressure stages. For both causes the danger is in the low pressure end, where large areas and weights and long blades give increased bending forces and lessened power of resistance.

Distortion may be due to wrong design, to use of improper material or to careless operation. Some cases of improper material were illustrated in the issue of Jan. 1, 1918, and a recent accident in Boston gave striking evidence of what may come from unexpected load conditions.

In trial runs of a 35,000-kw. turbine installed in the O St. station of the Boston Elevated Railway Co., somewhat over a year ago, the 18th guide blade diaphragm was distorted, causing a rubbing of blades of the 18th wheel, and resulting in stripping blades on the 18th and 19th wheels, as well as injuring the corresponding diaphragms. Capacity was reduced, by closing the valve admitting steam to the 7th stage, and repairs were made, after which the unit was again put on full load service.

But as sudden overloads of 2500 kw. were frequent, and the unit did not carry these well, holes were drilled in No. 8 diaphragm, so that live steam could pass through from the secondary valve ring, giving higher pressures all through the low end of the unit to carry these sudden overloads. The unit then worked well and carried all overloads successfully. Specific conditions of operation were 200 lb. pressure, 200 deg. F. superheat and 29 in. vacuum based on barometer of 30 in.

On Feb. 14 last, as peak load was coming on, the Central Station which was tied in with the O St. station blew out, and dropped its load of 10,000 kw. onto the 35,000-kw. unit which was already carrying 32,000 kw. Just previously, some vibration and rubbing had been noticed, and this dumping on excess overload, caused the admission valves to open wide, increasing the pressure all through the low-pressure end like a hammer blow. The result was a serious distortion of the 18th diaphragm, fouling the 18th wheel and in turn the 19th and 20th diaphragms and wheels.

The steel carrying the diaphragms, also broke at the 18th diaphragm and the low pressure end dropped into the condenser damaging a number of tubes. In the mix-up the diaphragms, which were of cast iron, broke up and large pieces were hurled through the casing, breaking the bracket which supported the turbine bearings next the generator, as well as causing other damage farther away.

By vibration or perhaps by intuitive action of one of the operating crew, the throttle controlling admission of steam to the turbine was tripped or the damage might have been much greater, and loss of life, which was fortunately absent, might have resulted.

Two things seem to be established by the accident. It is desirable to use steel for the low-pressure diaphragms of these large units, even though the expense and difficulty of manufacture are considerably greater than for cast iron. And at the first hint of trouble the unit should be shut down and carefully examined. In this instance, the crew, thinking that the rubbing might be remedied by adjusting the thrust bearing, made the attempt, and the result of the delay was a damage of $200,000, and the complete disabling of the large unit. By shutting down at the first sign of trouble, the damage might, probably, have been greatly lessened, and the disabling avoided.

Everyone is liable to an error of judgment, and the inclination is to try to keep a unit running, but every machine, particularly if running at high speed, is liable at sometime to disarrangement; and for big units the only safe course is to shut down when any trouble appears of which the cause is not certainly known.

Liberty Loan Not a Call to Sacrifice

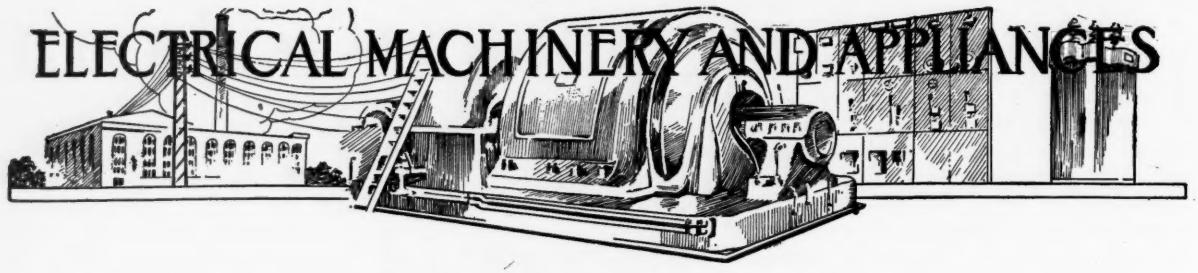
By Eugene Davenport

ALL war means loss. There is no way for anybody to profit in time of war except by means that are either disloyal or piratical. This war calls for sacrifice. Some will sacrifice their hands and arms, others their feet and legs, still others their eyes, and more than 10 millions of men, women and children already have sacrificed their lives in the great struggle to determine whether Liberty shall perish from the earth.

Every loyal man, woman and child will be willing to sacrifice all that he or she has to give. From this country only the soldier will be called upon to sacrifice life or limb; but everybody is called upon to sacrifice in food, in clothing, in comfort and in property.

The Liberty Bond is not a call to sacrifice. It is a financial investment at a rate higher than is afforded in many lines of business. The investment is as safe as the government itself. I wish sometimes that the Liberty Bond were a call to sacrifice, for if we lose the war it will be through the failure of our civil population to learn the lesson of sacrifice. Will the bonds be lost if we lose the war? Possibly, and so will the title to our homes. If we lose the war, the deed to the farmer's home is not worth the paper it is written on. Therefore, we economize, save, scrimp, wear old clothes, rake and scrape in every way to get funds for Liberty Bonds. Then shall we win the war. In no other way can it be done. How much are we who do not fight willing to sacrifice? How much will we earn and save in order to win the war?

A PARTY in Portuguese East Africa wishes to secure an agency for the sale of heavy hoisting machinery, coaling plants, cranes, railway and electrical materials. Correspondence may be in English, and further information may be had by writing to the Bureau of Foreign and Domestic Commerce, Washington, D. C., in regard to No. 26,793.



Electric Motors---II

TYPES AND CHARACTERISTICS OF MOTORS FOR USE ON ALTERNATING CURRENT CIRCUITS. BY GORDON FOX

THE GREAT majority of alternating-current motors are of the induction type. Induction motors are not as flexible as direct-current motors, and although widely used, the variety of applications is somewhat restricted by their lack of flexibility. Standard motors may be considered in three general classes, namely: Commercial general utility motors, crane and hoist motors and mill type motors.

The general utility motor is a competitive design of light weight and open construction. Motors of this type may be obtained with either squirrel cage or wound motors. These motors are adapted and widely used for driving continuous running machines at fairly constant speeds. They are normally rated on a continuous duty basis.

The frame or stator of the ordinary induction motor comprises a skeleton ring containing the stacking for the primary winding. The primary is nearly always located in the stator because of ease in introducing the primary current and because it carries the higher voltage winding which can thus be better insulated. The frame may entirely cover the stacking or may leave it exposed for radiation, the latter arrangement being preferable. The bearings in all but the largest motors are built in brackets attached to the frame. Provision is made in some motors for slight adjustment of the bearing brackets or of the bearings within the brackets to take up bearing wear and to maintain the air-gap. This feature offers some advantage in motors of the larger sizes.

The entire magnetic circuit of an induction motor must be finely laminated to reduce eddy current losses, as the magnetism is continually reversing. Ventilating ducts are not generally used in motors having narrow stackings, radiation being sufficient without them. In long cores, particularly in enclosed motors of the mill type, ventilating ducts aid in distributing the heating. End fingers should be provided to buttress the end laminations of the stacking to prevent chafing and noise.

The winding slots in the primary stacking may be of the open or partially closed type. Partially closed or overhung slots afford better distribution of the magnetic flux, reduce magnetic leakage and improve the characteristics of the motor. The use of overhung slots decreases the effective air gap by distributing the flux more uniformly. It also permits the reduction of the actual air gap, lowering the magnetizing current and improving the power factor. It is desirable for mechanical reasons, however, to have a liberal air gap, although this is attained through sacrifice in power factor. Open slots are not as desirable as overhung slots from the viewpoint of electrical design, but from a practical point of view they are to be preferred. With open slots the coils may be form wound and treated before they are assembled, while with closed slots the conductors must be threaded in singly. Not only are better insulating methods possible with formed coils, but repairs may be made more readily. Formed coils are more firm and solid, may be better braced and are better heat conductors. In general, the advantages of formed coils in open slots more than offset the disadvantages except, perhaps, in the very small sizes. The disadvantages of open slots are reduced in some designs through the use of magnetic wedges which produce an effect similar to that of overhung slots.

The primary coils, as above mentioned, may be either of the fully formed or of the threaded-in type. Diamond

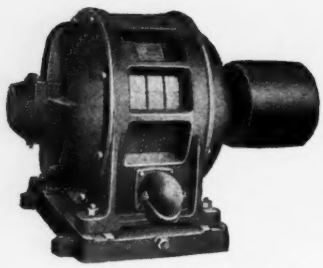


FIG. 6. A GENERAL UTILITY ALTERNATING-CURRENT MOTOR

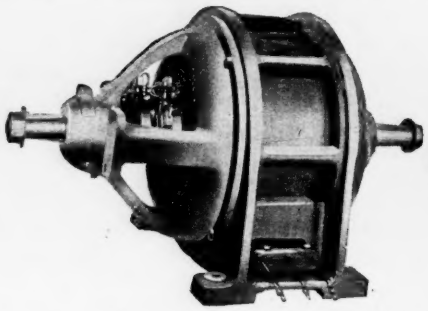


FIG. 7. ALTERNATING CURRENT CRANE AND HOIST MOTOR

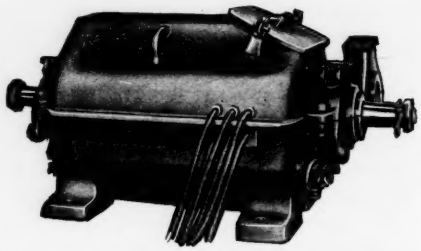


FIG. 8. ALTERNATING CURRENT MILL TYPE MOTOR

coils and basket coils are the types commonly employed for motors, basket coils being used only for small motors with overhung slots. Diamond coils may be used with either open or partially closed slots. They are easily manufactured and are suited to quantity production. Their symmetry and exact duplication results in electrically balanced windings.

The stator windings of ordinary induction motors are usually insulated with cotton, tape and other fibrous material of this class. Fully formed coils are thoroughly treated before assembling. Machines having threaded-in windings may have the entire stator subjected to the vacuum treatment if this is specified. This makes the windings solid and does away with air pockets and chafing spaces but renders repairs difficult. Special varnishes are available for application to the windings of induction motors where moisture or acid or alkali fumes may be encountered. This treatment is inexpensive and is to be recommended wherever conditions demand.

The span of the coils of induction motors is usually somewhat less than the pole pitch, since a gain is made through decreasing the end connections at slight reduction in the effectiveness of the turns. The windings are uniformly distributed and connected in groups with a number of coils per pole per phase. These groups are then connected in series or parallel and the terminals connected, in a three-phase machine, to make up a star or delta winding. It is usually possible to change the connections of the groups to adapt the motor for different voltages. In selecting a motor, it may be well to know for what voltages the machine may be adapted either for use in different plants or to make it suitable for the best local market as a secondhand machine. It is good practice to insulate the end coils of each group of coils with extra insulation, since the end coils of different phases are adjacent and are subjected to machine voltage. The terminal leads of the machine should be anchored to the frame to avoid damage to the winding through pulling on the leads. The bearing brackets should be designed to protect the end connections from mechanical injury.

The rotor of an induction motor should include a cast spider pressed onto the shaft, the stacking being mounted on the spider. The collector rings, when used, are generally mounted on a bushing pressed onto the shaft separately, and it is necessary to disconnect the rings to remove the shaft. Squirrel-cage rotors are very simple and rugged. Partially closed slots are generally used, the conductors being bars shoved through with the end rings connected to them. The conductor bars are ordinarily of copper. They may be round, square or of rectangular section. Deep rotor bars give high apparent resistance and low reactance at starting, with the opposite effect near synchronism. They tend to increase the starting torque, but may also diminish the stalling torque.

The end rings may be of copper or of alloy having higher resistance. Rotors are built to have high or low resistance, depending upon the slip and torque characteristics desired. The number of end rings may be varied to secure the desired resistance. End rings are usually of disc form to secure stiffness, several rings often being placed in multiple to provide heat radiating area. In squirrel cage motors most of the slip energy must be dissipated in the end rings. Fan blades are often provided to secure air circulation. Formerly most low resistance end rings were fastened to the rotor conductors by soldering with hard solder. This is not entirely satisfactory, due to the tendency to unsolder with overloads. A bolted construction using spring washers to provide uniform contact is commonly used for high resistance rings and has the advantage of withstanding high temperatures successfully. All methods of riveting have proved lacking, due to loosening caused by expansion and contraction. Most rotors are now brazed, welded or cast-welded, a very rugged and durable job resulting. End rings are sometimes supported by attaching to the rotor cores without insulation. Grounds have little influence in the ordinary squirrel-cage rotor, the secondary voltage being very low and the resistance of the iron circuit comparatively high so that little current is shunted from the short-circuited winding. The conductor bars may be insulated either with a paper cell or with a varnish before insertion in the core. In some cases the bars are inserted bare and the entire rotor surface is given a cement treatment after assembly, the cement penetrating and anchoring the bars firmly. In small squirrel-cage motors, it makes little difference whether the rotor bars are insulated or not. In large machines having appreciable voltage from one end of the bars to the other, local currents are set up through the stacking, reducing the starting torque but affecting running conditions little.

The stacking for wound rotor motors is nearly always designed with partially closed slots and these are frequently skewed to secure more quiet operation. Slot

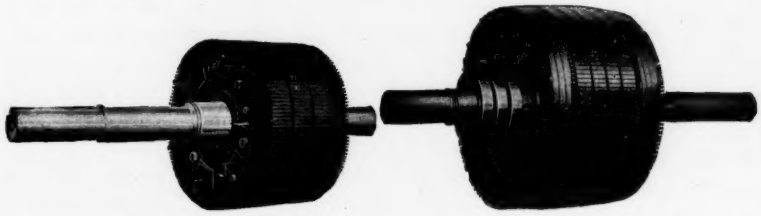


FIG. 9. TYPICAL SQUIRREL-CAGE ROTOR

FIG. 10. TYPICAL WOUND ROTOR

FIG. 11. TYPICAL THREE-PHASE STATOR

insulation is provided in the form of fish paper and treated cloth cells. The voltage of a wound rotor circuit is comparable with that of the primary and the coils must be well insulated from each other and from the core. The coils are usually of the diamond type, a wave winding being generally employed for convenience in connection. If made of wire they are threaded in one at a time, if made up of strap copper the conductors are insulated and inserted individually. Treated cotton tape is the usual conductor insulation, although sheet micanite wrapped with cotton tape is used for severe service machines. If a motor is to be used for reversing duty or if plugging is to be expected, the rotor insulation must be especially good, since approximately double voltage will occur at the instant of reversal. After insertion of the coils the cell insulation is folded over and wedges inserted. Bands are placed on the end connections, which should rest on shelves of the armature spider. The bands and shelves should be arranged not to obstruct ventilation of the end connections more than necessary.

Practically all wound rotors are connected three-phase, even though the primary winding is for a two-phase circuit. The primary and secondary windings are electrically independent, the magnetism maintaining relations between them, irrespective of their electrical connections so long as the magnetic conditions are correct. Rotor windings are commonly star connected, since this arrangement affords comparatively high voltage and low current in the external circuit together with the minimum number of turns on the rotor winding.

The collector rings may be of iron or bronze. Iron is quite satisfactory and, being cheaper, is generally used. The collector rings are preferably mounted inside the bearing bracket where protected. The brushes may be of copper gauze or carbon or metal graphite, the latter being generally preferable. Box type holders are generally employed. There should be more than one brush per ring.

Crane and hoist motors are always of the wound rotor type. They are usually of the open type, sometimes nearly identical with the general utility design. They are rated on an intermittent duty basis. The rotors should be of small diameter and insulated for plugging. It is well to have the shafts extra strong and the rotor coils well braced. This service being quite severe, the construction should be sturdy throughout, little being compromised because of cost.

Mill type motors are similar in external appearance, dimensions and design to their direct-current prototypes. They are not as extensively used as direct-current mill motors, due to their lesser flexibility and adaptability to control. They are totally enclosed. The rotors are long and narrow to reduce the inertia and permit rapid reversal. Wound rotors are used exclusively. The frames are split, as in direct-current mill motors, and the stator ring is fitted into the frame so that it can be lifted out with the rotor. High temperature insulations are used. The design is particularly rugged throughout. The general mechanical features are the same as in direct-current mill motors.

Why the Central Station Won

By a Subscriber

RECENTLY an isolated electric plant went over to a central station without considering the possibilities of using the exhaust steam then available or the kind of service which might be realized from a well-kept -up-to-date system.

The steam plant consisted of six 100-hp. water-tube boilers served by down-draft furnaces, and supplied steam for the following purposes:

For generating approximately 720,000 kw.-hr. energy a year; for operating a 20-ton refrigerating plant; for heating the buildings that accommodate 1,500 people; for laundering 17,000 pieces a week and hot water for other domestic uses such as dish washing, bathing, etc. As no meters for hot water are used, the number of gallons of hot water is not known. Steam is also used for cooking 3700 meals daily.

Here are some of the operating conditions in this plant and we wonder if they are not common to many others. Flue gas analyses were recently taken extending over a week and showed an average of only 5.5 per cent of carbon dioxide, CO_2, present in the gases. A maximum of 9.7 per cent of CO_2 was obtained only once and a minimum of 3.5 per cent of CO_2 was registered many times during the test. With 5.5 per cent of CO_2 an approximate preventable fuel loss of 21 per cent would amount to 1638 tons per year, as approximately 7800 tons of bituminous coal is consumed during this period.

As no experienced firemen are used at this plant it was suggested to the manager of this concern that an improved type of furnace and automatic stokers could be installed to serve these boilers more economically; he replied that this would be a waste of money, as the cost of labor in this plant is nothing and anyone could shovel coal under a boiler—a very true statement.

During the heating season, exhaust steam from the engines operating the electrical units is turned into the heating system and live steam through reducing valves is supplied to make up the remainder. The heat laden exhaust steam from the refrigerating plant and its auxiliaries goes directly to the atmosphere. Exhaust steam is not employed for heating any of the water for domestic uses.

The operating methods and conditions in the boiler plant could be improved, for as soon as a boiler is put into operation the uptake damper is chained wide open and kept that way until the boiler is taken off for cleaning, which consists of blowing down with 60 lb. steam pressure.

Approximately 280 per cent of excess air is passing through the furnace and over the boiler's surfaces, filtering in through poorly fitting furnace doors and cracks in the brick work.

The flue gases are much hotter than they should be, as the baffle plates are broken and displaced, so a large per cent of the hot gases can take a short cut to the chimney.

The cost of operating this plant could be reduced very much by giving attention to and remedying the following: Blow-down valves on these boilers leak so much that the pipes leading from them to the sewer are as hot as any of the other pipes leading from the boiler.

Boilers are repeatedly put back into service, although the tubes leak so badly that fires cannot be maintained on one-fourth of their grate surfaces. Large steam leaks are permitted to exist for months.

When all this wastefulness is figured up and put against the amount of money it would take to put this plant into splendid operating condition and on an economical basis, one can see how this plant could furnish electrical energy more cheaply than it ean be secured for from a central station.

Some Refrigerating Plant Experiences

By Edward Wolff

THE engineer engaged to run a fifty-ton ice plant installed in a small country town had never seen a refrigerating machine and was somewhat nervous about taking charge of it, but as he was a relative of one of the owners they wanted him to take the job and were quite convinced that he would not have any trouble with it. Besides, one of the owners had had some experience with ice machines while employed as bookkeeper in a cold storage plant and volunteered to help out in case the engineer became involved in difficulties.

About two months after the plant had been installed we received a hurry-up call from the owner to come and see what was the matter with the plant, as it would not do the required work. Arriving on the job, I found the suction pressure much lower than it should be according to the brine temperature at the time; the condenser pressure was also considerably lower than would be expected with the temperature of the condenser water supplied, and the machine was running hot and there was not a sign of frost on either machine or suction line.

Anybody who has operated an air compressor is familiar with the characteristic swishing sound in the air receiver with each discharge of the compressor. There was exactly the same sound in the ammonia receiver. From this it was quite evident that there was little, if any, liquid in the receiver and that it was mainly gas that was circulated around the system.

I found further evidence of this when I came into the tank room. The uncovered sections of the liquid line were covered with a soft, light, slushy frost that could readily be brushed off with the hand, leaving the pipe bare until the frost would again form.

The expansion valves were nearly wide open, whereas in normal operation they should not be much over a quarter to half a turn open. This in connection with the low suction and condenser pressures, the peculiar sound in the ammonia receiver, the absence of frost on the compressor, suction line or any of the suction valves on the tank as well as the soft frost on the liquid line and expansion valves was pretty good evidence, according to previous experience, that there was only a fraction of proper ammonia charge in the system.

According to the engineer, they had had no leaks of any consequence. They had had a little trouble with the stuffing box, but not enough to make any appreciable "stink" in the engine room at any time. Furthermore, this had happened only four or five times in the two months the plant had been in operation and it was out of the question to assume that all the ammonia had been lost in this manner.

I finally got some sulphur sticks and tested every joint in the place for leaks. Next I obtained some litmus paper and tested the brine in the tank. In neither case did I find the slightest sign of a leak. I next tried the jacket water of the compressor with the same results. Finally I went up on the roof and tested the return water from the condenser, where I found the litmus paper showed signs of considerable ammonia.

Evidently there was a leak in the condenser, which was of the double-pipe type. The sulphur stick showed no signs of a leak on the outside joints, so that the troubles must evidently be in some of the inside water pipes. To determine in which one of the stands the leak was located, we shut off the circulation for about half an hour so as to let the water in the defective stand get thoroughly saturated with ammonia from the leak. We then drained the coils one at a time and when we came to the defective coil we had no trouble in detecting it; the litmus paper turned red in a flash. By holding the sulphur stick near the water we could also detect the ammonia rising from the water, which indicated a pretty serious leak.

The coil was then cut off at top and bottom, all the water drained out and the rest of the coils cut back in service. We then removed all the return bends from the defective coil and when we were ready the coil was cut in again and a pressure of about 200 lb. placed on the condenser. While this was being done, we passed sulphur sticks back and forth in front of each end of each pipe of the defective coil.

The defective pipe was detected by the fumes escaping from it as indicated by the sulphur sticks. As soon as the pipe was definitely located, the coil was pumped out and the pipe removed. The pipe was then capped on one end and the other end connected to an air pipe by means of a hose and lowered into the brine tank a few inches below surface of the brine. The air pressure was then turned on, when the defect was found to be near the center of the pipe, as indicated by air bubbles rising to the surface of the brine.

The pipe had been split in the weld for some 2 or 3 in., as could readily be seen after it had been removed from the tank, once the exact location had been found by the test.

To prevent further trouble of this kind, I advised the engineer to test the condenser water, jacket water and brine regularly every week. Some Nessler's solution was provided for the purpose, as this is much more sensitive than the litmus paper test, which will not indicate the presence of small quantities. If this had been attended to regularly before this pipe split, the com-

pany would not have had to put in about 750 lb. of ammonia to bring the charge back to normal.

It is the little things that generally worry the beginner the most. Some time ago a friend of mine assumed charge of a plant which included two 150-ton horizontal Ball ammonia compressors of the old style with the suction under and the discharge valves on the top of the cylinder. He had had but little experience with compression ammonia systems, although he had run a small absorption plant and he took the job on the assurance that I would help him out if at any time he should be in a pinch, as my plant at that time was only a block away.

One day one of the oilers came over and asked me to come over as soon as possible; one of the compressors was making a terrific racket and they had shut it down to prevent it from hammering itself to pieces. We got the machine started again and the racket was rather severe to say the least. Apparently it came from some place in the cylinder and I finally decided to investigate the discharge valve first. On the first valve that we removed we found the trouble—nothing but a broken spring. The valve was large and quite heavy and with the spring gone it closed with a severe slam at the finish of the discharge stroke, or rather when the piston started on the return stroke, and the sudden rush through the opening pulled the valve shut with a slam that sounded much like somebody pounding on a large pipe with a sledge hammer.

Some time later a new trouble appeared. One of the machines developed a knock that appeared at infrequent intervals. The engineer had removed the valves and looked every place without being able to locate it. Finally he gave it up for a bad job and asked me to come over the next time it appeared.

This happened a few days later. After watching the machine a few minutes I tightened up on the stuffing box nuts gradually and finally the knock stopped. Everybody was much mystified as to how this would affect the knock, but it was simple enough after I explained to them that there evidently was a junk ring in the bottom of the stuffing box and that when the packing was too loose it allowed the junk ring to play back and forth and strike the bottom of the box with sufficient force to cause the knock. I had had the experience several times before, so it did not require any effort on my part to locate the trouble.

One day one of the stuffing boxes began to give an unusual amount of trouble. If it was attempted to keep it tight enough to prevent leaking, it would get hot and burn the packing, and if it was loosened up it began to leak. It was repacked twice in three days without better results. I was finally asked to come over and see what I could suggest to overcome the trouble.

After attempting to adjust the nuts on the gland for some time without any better results than the others had accomplished, I finally decided to investigate the gas relief line from the top and center of the stuffing box to the suction line. When I got this disconnected, I found that it was filled with shreds of packing and packed so tight that it required the services of a packing hook to get them out. After these were removed, there was no further trouble.

Some time later, a light thump appeared in one of the compressors at irregular intervals. After watching it for a period of several weeks, the operating force came to the conclusion that it was in some way connected with the temperature of the machine, as the thump never appeared when the machine was warm. When the machine was very cold, the thump was quite severe and gradually disappeared as the machine came up to normal temperature again.

The trouble in this case was due to lack of proper care in taking up on the main bearing. This had been taken up just before the trouble started and in doing so they had shifted the main shaft enough to bring the piston practically up to the head of the cylinder when it was at normal temperature. When the rod cooled down to very low temperature (as it would when the machine would run very cold) the rod contracted sufficiently to bring it up against the head with a thump. Readjusting the bearing eliminated this trouble.

When the weather began to get cold the engineer attempted to shut down one of the machines and carry the load with one machine. As soon as he did so, the ammonia would begin to disappear from the gage glass in the receiver and after 3 or 4 hr. it would be gone entirely. After a while, the frost would begin to disappear from the machine and it was impossible to keep it frosted for any length of time, although the expansion valves were gradually opened until they were wide open. The frost then came off the expansion valves also and the cooler temperatures went up at a rapid rate and the second machine had to be started again. This happened every time it was tried and it finally was put up to me for solution.

It was my first experience of this kind at that time, and I had some trouble before I finally located the cause. I spent considerable time pumping out and experimenting with the expansion coils before I finally went up and examined the condenser. In going over this, I found a number of the coils were cold and apparently not working. Generally cold condenser coils are due to an accumulation of air and foul gas in them, and I purged them thoroughly. This, however, failed to produce the desired results; as soon as we attempted to run with one machine about 12 of the 30 stands would get cold and quit working no matter what we did.

After some experimenting, we found that if we cut out nine of the coils the remaining 21 would keep on working and prevent the ammonia from hanging up in the condenser. It seemed that, with the entire condenser in operation, the ammonia would accumulate in the dead coils and refused to come down, although, if we cut out some of the other coils, these coils would start working and the ammonia would come down and there would be plenty of it. I have had the same experience in a number of cases since that time and I never have been able to make a satisfactory explanation of it. The ammonia will hang up and refuse to come down if one of the machines is shut down and the same amount of water is left to run over the condenser; it will not do this in all cases, by any means, and on some systems you can run anywhere from one to three machines on one condenser without trouble, while with the others, if you shut any one of the machines down, the trouble commences.

Conservation of Ammonia---II

Constant Leakage Around Rods, Joints and Valves. By A. G. Solomon

THE SECOND and by far the most common way of losing ammonia is by what may be termed constant leakage. This may be divided into two classes; one visible and easily located, and the other the invisible leakage.

Most visible leakage occurs at the ammonia piston rod and this cannot be excused. The causes are several, but all can be easily overcome and the loss prevented. The common causes are: Rod out of line with the cylinder, owing to improper adjustment of the crosshead shoes. To remedy, the shoes must be set up so that the rod will caliper central in the guides at all parts of the stroke. The crosshead must also be keyed tight enough so that there is no play between the guides sufficient to allow the rod to leave the central position.

If the piston is too small for the bore of the cylinder, it will have the same effect as the rod being out of line with the guides. To remedy this, the cylinder may have to be bored and a new piston fitted.

The next cause may be scored or worn rods. If a rod is so rough as to cut or tear the packing, it must be turned down in a lathe. Or if the rod will not stand more turning a new rod must be put in.

A common cause of rod trouble and ammonia leakage is the fit of the rod in the gland, oil lantern and neck ring. It must be borne in mind that a rod does not expand a noticeable amount so as to increase its diameter when a proper running heat is maintained. As this is true, the gland, lantern and neck ring should be babbited and bored out to just a sliding fit on the rod, Fig. 4. They should also be a snug fit in the stuffing box. This close fitting is absolutely necessary to keep the packing from tearing.

Regulating Temperatures

With the rod in line and all fits made right, no leakage will occur if the ammonia is handled as it should be. Find out what discharge and suction temperatures (not pressures) give the best results with the type of machine used, and then maintain these temperatures. This temperature control will be regulated by the degree of saturation of the vapor entering the cylinder. The closer to the saturated state in which the vapor enters the cylinder the greater the weight of ammonia displaced by the machine.

Place a thermometer in the suction line close to the compressor and try to hold the vapor at that temperature which corresponds to the suction pressure. Refer to a table giving temperature and pressure relations of saturated ammonia.

After some practice, it will be found just how close to the desired temperature the ammonia can be sent into the cylinder without the loss of ammonia through the rod packing.

But do not go to extremes. The temperature of saturated vapor, at a given temperature, cannot be lowered by increasing the degree of saturation; therefore do not freeze up the machine more than necessary and by so doing handle a vapor so wet that the machine will pound and the discharge line have a temperature below 160 deg. F.

If the suction temperature can be carried at from 1 to 3 deg. higher than the temperature which corresponds to the pressure, the machine will give excellent service and the rod packing will give no trouble. Allowing the suction temperature or the degree of saturation to vary will cause leakage of ammonia, as no packing can adjust itself to the sudden and extreme temperature changes to which some engineers subject it.

The Piston Rod

Proper lubrication is as necessary on the ammonia rod as on any bearing of the machine. Do not think that because the amount of ammonia oil used is small it can be neglected.

All stuffing boxes on ammonia rods are provided with a chamber, commonly called the oil lantern or sleeve.

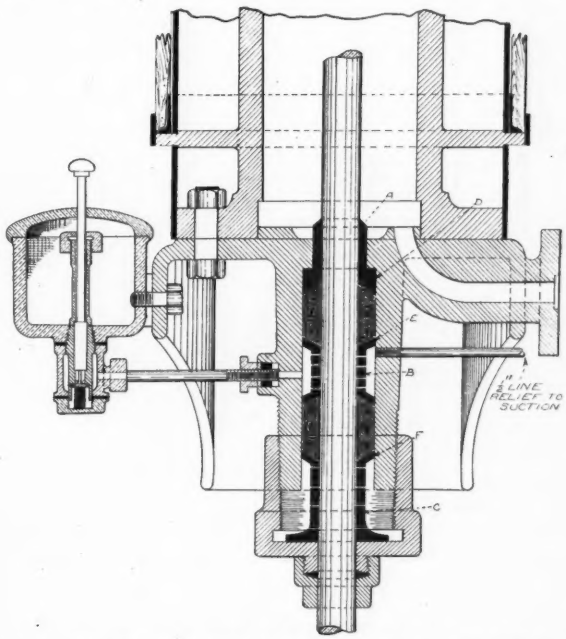


FIG. 4. BABBIT AND BORE TO CLOSE SLIDING FIT AT A, B AND C. SNUG FIT AT D, E, AND F

Two openings connect into this lantern through the stuffing box walls. One opening (usually at the bottom) is connected to the oil supply, which may be a reservoir or tank, or may be either a hand or mechanically operated oil pump. The other opening is connected into the suction side of the compressor and is for the purpose of maintaining suction pressure inside the lantern.

If too much oil is used, the oil passes out of the lantern through the gas relief line and into the system. As oil is not wanted in the system, care must be taken that too much oil is not pumped through the lantern. Regulate the oil feed just as carefully and with as much practice as you do the feed of the lubricator which supplies the steam valves and cylinder with oil.

The gas relief line also requires some attention. Small particles of rod packing will lodge in the globe valve found between the stuffing box and the suction line. These particles will gradually block the valve, and ammonia leaking through the packing between the lantern and the bottom of the stuffing box will keep a high pressure inside the lantern. This high pressure will prevent the regular supply of oil from entering the lantern and will also cause ammonia to blow through the few rings of packing which are between the lantern and the gland.

When such conditions are noticed, the relief line must be disconnected and the obstruction removed.

Excessive leakage of ammonia from the cylinder to the lantern will be noticed in one of two widely different ways. If the compressor is being operated with dry or superheated gas, the relief line, Fig. 4, will be heated by ammonia escaping from the lantern to the suction line. If the compressor is handling heavily saturated vapor the relief line will frost over when leakage occurs. In either case, this leakage is really a bypassing of ammonia and greatly reduces the capacity of the machine.

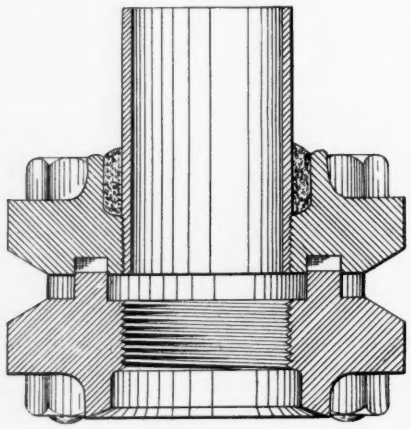


FIG. 5. SECTION OF SOLDERED JOINT, FLANGE TO PIPE

The oil lantern not being in its proper position is also a cause of ammonia loss. If the lantern is not in communication with the oil inlet and the gas relief the rod will not be lubricated.

Small Leaks

Small leaks in the system are another visible loss of ammonia. Such leaks occur at valve stems, valve bonnets, flanges and where flanges or fittings are made up on the pipe and also in the pipe itself.

After a machine is shut down and the discharge line cools, small leaks often become evident and are allowed to continue, for "they will take up when the machine is started up again." This neglect of leaks is a mistake. If a flange or any other joint leaks when the line is cold, it must be fixed. Make all parts of the system so that ammonia will not escape when temperature changes occur.

Leakage at valve stems can easily be stopped. There are few ammonia valves that cannot be repacked when the valve is open wide. If a valve stem leaks and it looks like a case of pumping out part of the system to pack it, at least try to pack it when the valve is jammed wide open. There may be a little smell, but it won't hurt, and in most cases the loss of ammonia which escapes during the few minutes it takes to slip in a ring of packing will not harm the system as much as the air that may be drawn in if a vacuum is pumped.

Often when a valve is closed tight, the joint, J, Fig. 2 (p. 377, May 1 issue), between body and bonnet will leak owing to the bonnet being raised by the pressure exerted in forcing the disc down hard on its seat. If this leakage occurs, the valve should be opened again a few turns and the bonnet tightened. Don't allow it to leak and say that it will quit when the valve is opened.

When a leak is found where a flange or fitting is made up on a pipe, the first thing to do is to see what kind of a joint it is. If it is a sweated or soldered joint, Fig. 5, a small leak can usually be stopped by calking. The tin in the recess can be forced into the defective thread and the joint made tight. But such work much be considered as only temporary. At the first opportunity, take off the flange or fitting and make it up right.

Litharge or other cement joints cannot be calked, so when they leak the only remedy is to make a new and tight joint. Plan the work to be done and have everything ready, and very little loss in capacity will result.

Leakage at gaskets is also common. If a flange cannot be tightened up owing to rusty bolts, new bolts must be put in. If a flange having four or more bolts is troublesome, one bolt at a time can be taken out and a new one put in its place. When this is being done on a high-pressure line, it is safest to lower the pressure by pumping down to back pressure. Give all bolts a coating of graphite and cylinder oil, and rust will not be the cause of future trouble.

Welding up of the plates of ships is now proposed in place of riveting. One method would be spot welding, by welding spots in the plates instead of punching and riveting. Tests of this form of joint show that the plate gives way rather than the welded spot, when subjected to tensile stress.

The second method is continuous fusing of the seam, doing away with calking. In some experiments on making bulkhead doors, the plates were spot welded and then the edges fused down in place of calking. It is estimated that the work of joining plates can be done in half the time by welding that is required for punching and riveting, and costs may be somewhat reduced, though that is a secondary consideration at the present time.

U. S. Civil Service Commission announces an examination for electrical draftsman, for both men and women. Vacancies in the Bureau of Steam Engineering, Navy Department, for duty at Washington, D. C., or at any navy yard or other naval establishment of the United States, at entrance salaries from $4 to $6.40 a day. Competitors will be rated on physical ability, education, training and experience and must have reached their eighteenth birthday on the date of making oath to the application. Until further notice, applications will be received at any time.

Temperatures of Furnace Air and Flue Gases*

COMPUTED SAVING DUE TO INCREASING TEMPERATURE OF AIR SUPPLIED TO FURNACE AND DECREASING FLUE GAS TEMPERATURE. BY W. F. SCHAPHORST

IT is becoming more and more the practice to burn as little coal as possible—to save coal even though apparatus of rather high cost must first be installed. There are various ways of doing this. Some plants use feed-water heaters, some install more efficient engines, turbines, or transmission systems, some install economizers, and so on. Some of the largest and most up to date plants install *everything* that can be proved to be a wise investment. The latest economy kink to be utilized is "warm air" for feeding to the furnaces.

For example, electric generators "heat up" when they generate current and in many installations nowadays they are cooled by means of fans to keep the temperature from going too high. The air itself used for cooling the generators is, of course, slightly heated, and in most installations of today this heated air is permitted to co-mingle with the cooler atmosphere again, which is a dead loss. Heat should be conserved wherever it can be done profitably.

Up-to-date engineers, therefore, are utilizing this "waste heat" to advantage in many instances. The warmed air from the generators is carried in ducts to the furnaces, thus lessening the labor of the coal and saving heat.

On the average, allowing extra air to permit complete combustion, each pound of coal requires 18 lb. of air.

Inasmuch as 0.24 B.t.u. is required to raise the temperature of 1 lb. of air 1 deg. F., it is evident that much of the heat value of the pound of coal is lost in simply bringing the temperature of the cold air up to the temperature of combustion. For each degree (0.24×18) 4.32 B.t.u. are lost. For each 100 deg. 432 B.t.u. are lost. If the heat value of the coal is 10,000 B.t.u., this preheating therefore represents a loss of $(432 \div 10{,}000)$ 4.32 per cent.

It is now evident that this preheating proposition is nothing to be shoved away lightly. In these days of high coal prices and coal scarcity it should be taken seriously.

To aid the reader in figuring his own conditions, the writer has therefore constructed a chart, presented in the Practical Reference Tables. Lay a straightedge across the chart twice, as indicated by the dotted lines, and column D will immediately give the approximate saving that can be effected by perheating the air.

For example, if the heat value of your coal is 10,000 B.t.u.; if you are spending $10,000 per year for coal; and if you could preheat the furnace air at least 80 deg. F. the year around, how much money would be saved per year?

Run a line through the 10,000 (column A) and the $10,000 (column B) and locate its intersection with column C. Then from that point of intersection run over to the 80 (column E) and where the line cuts column D you will find the answer—very close to $350.

In other words, if it would cost $7000 to install the ducts, fans, etc., the saving would amount to only 5 per cent of the investment. That would hardly be enough to cover interest, upkeep, power, depreciation, etc. If the first cost would be $3500, the saving would amount to 10 per cent, which is better. Perhaps the first cost would be only $350.

Obviously, then, this method of saving coal and money is worth investigating. The writer does not claim the chart to be absolutely accurate, but it is based on average conditions and will handle most cases very well. Perhaps you are wasting heat in some way or other now and the chart will prove of value to you.

VALUE OF LOW CHIMNEY GAS TEMPERATURE

TO SAVE as much coal as possible, one of the things necessary in the power plant is to maintain the lowest practical temperature in the chimney or waste gases. Hot gases are useful for creating natural draft, but they are very wasteful. It is usually more economical and better to install a mechanical blower for creating forced draft and exhausting the waste gases into the atmosphere than to allow those gases to pass away at a temperature of 600 deg. F. or thereabouts. Engineers, therefore, are advocating the use of temperature recording instruments in the boiler room for keeping a record of the waste gas temperature. If this temperature runs up to 600 deg. or even 550 deg., there is a loss. It is the duty of the engineer to see to it that a low and efficient temperature is maintained.

The best way to maintain low waste gas temperatures is to keep the boiler tubes clean both inside and out. Keep the soot deposits off the outside. Keep the scale deposits off the inside. By doing this the tubes are enabled to transmit heat easily and the temperature of the gas will approach the temperature of the water in the boilers. It is impossible, to be sure, to maintain a lower temperature of waste gas than the temperature of the steam being generated without the additional use of an economizer, a mechanical draft equipment, or some kind of interchange system. The day will doubtless come when in large power plants the waste gas temperature will be very close to the initial temperature of the feed water, which is frequently real "cold."

If the combustion of coal were a "perfect" process this chimney loss would not be so serious a matter, but combustion is invariably imperfect. It would be mighty nice if we could get along with the amount of air "theoretically" required, but it "can't be done." In order that combustion may be complete it is the universal custom to supply more air than the theoretical amount. One authority states: "Thirty to 50 per cent above that theoretically required, or 16 to 18 lb. of air per pound of fuel, is necessary to insure perfect combustion; but in only a very few plants is the air supply maintained at this point. It is often found to run from 100 to 200 or 400 per cent excess, entailing great loss of heat in the hot chimney gases."

To refrain from exaggeration, let us assume that in the carefully fired plants 18 lb. of air is used per pound

*Copyright by W. F. Schaphorst.

of coal fired. Since most of the pound of coal is itself converted into gas we have an extra pound to contend with, or a total of 19 lb. of burned gases passing out of the chimney per pound of coal fired. The specific heat of this gas is usually taken as 0.24. That is, 0.24 of a British thermal unit is required to raise the temperature of one pound of the gas one degree Fahrenheit. So, multiplying by 19, we get 4.56. Now, multiplying this by the excess temperature that is being permitted. The excess temperature is the actual temperature of the waste gases "before" the tubes are cleaned, minus the actual temperature "after" the cleaning, or (T-t). Thus, if the temperature before cleaning is 600 deg. F., and after cleaning, 500 deg. F., the difference or excess is 100 deg. F. Multiplying by 4.56, we get 456 heat units lost per pound of coal fired.

Lastly, divide this by the heat value of the coal per pound. Thus, if the heat value of the coal is 12,000 B.t.u., we get $456 \div 12{,}000 = 0.038$. In other words, the loss is 3.8 per cent.

To assist in performing the above mathematical operation quickly, the chart has been prepared, and is shown in the Practical Reference Tables. It is based on the cited figure—18 lb. of air per pound of coal, which is necessary to insure thorough combustion.

By simply laying a straightedge across the chart connecting the heat value of the coal (column A) with the temperature decrease (T-t) shown in column B, the intersection of the extended line with column C gives the coal saving in per cent.

The dotted line drawn across this chart shows how the problem solved above is worked out by means of the chart. Column C, it will be noted, gives the answer as 3.8 per cent.

The range of the chart is great enough to cover any ordinary power plant condition—any coal and any probable temperature decrease. But it must be remembered that the chart is "very conservative" and that in most plants the loss is greater than shown by the answer obtained in column C, because of the fact that in actual practice a greater excess of air is used than 50 per cent.

A permanently installed soot cleaner will keep the outside of the tubes clean at all times, provided, of course, the engineer takes enough interest in his plant to turn on the steam three or four times per day and swing the soot-cleaning elements around. It is a very simple and convenient process—much superior to the old hand lance method. There is about as much difference between the old and new methods as there is between inefficiency and efficiency. The hand lance method is inefficient because it is not thorough, because the boiler must be shut down, because it is dangerous, and because it is hard, distasteful work.

The effect of scale removal is the same as the effect produced by cleaning off the soot. It gives the heat a chance to get through, thus lowering the temperature of the waste gases. To remove scale effectively, there is no better method than by means of a boiler tube cleaning machine, used regularly. Mechanical cleaners have been greatly improved of late and no power plant should be without one. Manufacturers are so sure that cleaners of this kind will give satisfaction that they send them out for free trial without obligating the prospective purchaser in any way.

The writer would suggest that a soot cleaner and scale remover be tried out fairly. Measure the temperature of the flue gases "before" cleaning, and again "after" cleaning. Subtract and then use the chart. You will doubtless find the cleaner to be a paying proposition.

Notes on Hydraulic Turbine Construction

By F. G. Switzer

THE purpose of these notes is to enable the engineer, who occasionally has such work, to pick out an hydraulic turbine. It is not intended to cover all considerations; a large and important plant should be considered from a different standpoint.

It is presumed that the size of the units has already been determined. The following data will be required in addition to this; head available; head variation; money value of efficiency; storage or pondage possibilities; and speed of units.

The head available is subject to variation with the load, due to losses in the pipe line or other water-carrying channels. The first value to be found is the total available drop from head water or reservoir level to the tail race. If this is subject to variation due to high water or dropping in level in the reservoir or storage pond, due consideration should be given this point. The available head should be taken as that which will be found the greatest part of the time.

It is very frequently found that the turbine must be set at some distance above the tail race level, in which case this distance should be measured. In case an impulse type of turbine is used (commonly called a tangential wheel) this height is lost as far as the turbine is concerned. With a reaction wheel this head or fall is largely made available by the use of a draft tube. In no case should the height from the tail race to the shaft of the reaction wheel exceed 20 to 25 ft.

Having determined the total head available (deducting the height of turbine above the tail race level in the case of the tangential wheel) a correction should be made for the losses in the water-carrying channels leading to the turbine. In many text books on hydraulics or in handbooks formulas may be found for this computation. The loss should be calculated on the basis of the amount of water required at full load. The net head is then the difference between the total head available in this loss. In case the head variation, due to high water or drop in reservoir level, exceeds 10 to 15 per cent of the head calculated above, this variation should be noted when asking for quotations on the turbine.

If water is scarce and the power made available by decreased losses could be sold to advantage, the value of this power should be capitalized. In this way it may be determined how much more may be paid for a turbine of higher efficiency than for one of lower efficiency. In most plants this is of little importance.

The value of storage or pondage should be determined in a similar way. The value of the power made available by the storage can be figured and offset against the cost of the construction necessary to procure the storage. This computation enters into the problem of determining the size of the units. The greater is the storage, the greater will be the total installed power.

In order to complete the selection of the turbine it is now necessary to determine the speed desired. This may be facilitated by the use of the constant which is sometimes called "characteristic speed" or "type characteristic." It will be denoted here by the symbol N_s. Its value may be found from the expression

$$N_s = N\sqrt{b.hp.}/h^{1.25} \qquad (1)$$

in which N is the r.p.m.; b.hp. the brake or delivered horsepower; and h the net head available after deducting losses. Referring to the charts in the Practical Reference Tables, a graphical solution of this expression may be made. The net head and the horsepower of the unit having been determined, lay a straightedge across the value of these two on their respective axes. On the central unmarked axis mark the point of intersection with the straightedge. Now lay the straightedge across the axes of characteristic speed and r.p.m., the line passing through the mark on the central axis. The intersections on these two speed axes will give the possible combinations of these two variables. It will be noted in the chart for impulse turbines that this has been done with the following data, 5000 hp. under a 1500-ft. head. The line connecting these two points is drawn in as a full line. Through the intersection of this line with the central axis a dotted line is drawn between 600 r.p.m. and the characteristic speed of 4.5. It will be noted that if a higher r.p.m. is desired the value of characteristic speed will be higher. In this way a number of combinations may be determined and the one selected will depend upon the r.p.m. desired or the value of characteristic speed which is best suited to the plant. These charts are different only in the range of values. One includes low values of characteristic speed such as are found for the tangential wheel. The other is for the reaction turbine. The scales are all logarithmic and may be readily extended where necessary.

The usual range of characteristic speed is:

Tangential wheel	up to 4.5
Reaction turbine	12 to 85

Tangential wheels are used with values of N_s up to 6 or so, but these high values entail some sacrifice in efficiency. Values below three are rarely found except in plants with very high head in comparatively small units. No loss in efficiency is usual with low values. Reaction turbines have been built with values of N_s from 10 to 100 and it is understood that even higher values will soon be possible. These high values involve lower efficiencies. The most efficient turbines will be found in the ranges of N_s up to 4.5 and between 30 and 60. As would be expected, higher efficiencies will be found in larger sizes than in smaller ones under similar conditions.

For very low head plants, where the head variation due to floods or low water periods is considerable, there is a decided advantage in the use of a high value of the characteristic speed. This is due to what is technically known as "over-gating." The design of these turbines is so effected that under normal head the maximum efficiency occurs before the turbine gates have been opened to their maximum discharge position. This point of maximum efficiency is usually called normal gate opening. It may often be found that the efficiency falls off so rapidly with increased discharge that the power output may be diminished at larger gate openings. When the head drops to abnormally low values this is no longer true. It would ordinarily be expected that the power output of a turbine would decrease with lower head in the ratio of the three halves power of the heads. Thus

$$hp._1/hp._2 = h_1^{1.5}/h_2^{1.5} \qquad (2)$$

On low heads the efficiency at larger gate openings than normal may not drop off, but may increase. By opening the gates to their maximum discharge position, the power output may be materially increased above the value found from equation 2. This will help to keep the power output up at times of low head. In view of this peculiarity it should be the aim of the engineer to choose a turbine of high characteristic speed for those plants where the head will at times be very low.

Values of characteristic speed between 6 and 10 are impossible. If a solution indicates a value within this range some change must be made. Either the r.p.m. or the size of the units is the only factor, the variation of which will accomplish the desired result.—Sibley Journal of Engineering.

Here's How

By Channing Barnes

DOWN in the caverns of iron and steel,
Making the power for men at the wheel,
Toil the men of the stokehold.

Lit by the glare of a man-gutting hell,
Slicing its heart; o'er the rhythmical swell
Glide the men of the stokehold.

Far overhead there are others as brave,
Sighting the heavens and scanning the wave,
Borne by men in the stokehold.

Fear they the monsters that follow their wake,
Knowing their post is the target they'd make?
Not the men in the stokehold!

Men of our race who gallantly face
Death as it comes, with a debonair grace,
Hail the men of the stokehold!

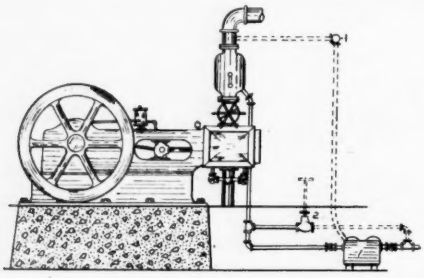
The following definition of an eccentric, applied by a lawyer arguing an engineering case before the court, may not be mathematically correct, but it is a fairly good description. The lawyer, having repeatedly referred to an eccentric, the judge at length asked him what an eccentric was; he said he was familiar with the term as applied to individuals, but not as applied to a part of a machine. The lawyer defined it as follows: "An eccentric," he said, "is a circular disk whose center is not in the middle."—Machinery.

Connecting a Steam Trap

THE HIGH-SPEED ENGINE in a plant was piped as shown in the sketch, float trap being connected up as shown by full lines.

The engineer experienced trouble with this trap and others getting air-bound, so he left the air cock, 2, slightly open. One day his assistant had a job to do on a line near trap 1, and noting the vapor coming from the cock, 2, closed it.

The engine was wanted in a hurry shortly afterward, and after opening the throttle for a few seconds with crank on dead center to warm up, was being brought up to speed when a crash came, breaking the cylinder head and a portion of the cylinder flange to which it was bolted. Investigation showed that the trap was air-bound and so failed to discharge the condensation from the steam main. Among other repairs made, the engineer reconnected the trap, 1, as shown by the dotted lines, thereby doing away with the possibility of the trap being air-bound and these connections together with



TRAP CONNECTED TO DRAIN STEAM SEPARATOR AND PROVIDED WITH BYPASS

the bypass shown, illustrate the correct manner to connect a trap to act as a throttle drain.

Before the engine is started, a hand wheel on an extension stem is put onto the regular hand wheel, as shown, and the bypass opened by hand.

When connecting traps of the float or bucket type it is admissible to fill the body with water to the usual water line, which will prevent steam blowing through until condensation can accumulate, and close the discharge valve. RECEIVER.

Saving Coal by Cutting Down Transmission Losses

DURING THE PAST 6 or 8 mo. much discussion and many suggestions have appeared in the general and technical press in the effort to conserve our nation's coal. All of these are good and proper and need constant repetition until people come to realize the necessity of economy in fuel. Improvement in power plant economy, cutting down boiler losses, teaching people how to care for and handle house furnaces, and many similar topics furnish excellent suggestions for such economy.

It seems to me that more attention should also be given to the saving of fuel by minimizing the power losses in mill, shop or factory, which is a matter that is often neglected and considered of too little importance to warrant attention. I am aware that in many plants the machinery and the transmission are highly efficient; but I am often astonished at the utter disregard of power waste in many other plants where dozens of machines driven by belt, gear, or other forms of transmission are used.

This power waste is caused first by the unnecessary use of machinery, machines running idle or operating at low load. It is a common occurrence to see several machines running idle for a considerable time and in most instances there would be no appreciable amount of time lost in cutting them out. It is just as common to see machinery and engines of all kinds operating at light loads and therefore with lower economy when slight changes in design, installation or method of operation would materially reduce the power consumption.

Then, again, power is often wasted in the machine or in the transmission. I have seen line shafts that resembled corkscrews and others that hung like wire cables suspended at the ends. Some bearings fairly groan under their mistreatment. Perhaps they are too tight, out of alinement, poorly lubricated or never cleaned out. The unnecessary loss of power in bearings is many times surprising.

In plants such as crushing or ore-treatment plants, bearings are frequently left exposed until one can almost hear the dust settle in and grind up, making an efficient pulverizer out of what is intended to be a bearing. A simple guard would largely prevent this.

One day, I watched two workmen tighten a belt by the usual screw tightener, shifting a machine on its base and I wished the belt would snap and slap them for their cruelty to the hides of animals. The tension must have been several times the proper working load; yet it stood the strain. But what an enormous pressure must have been placed on the bearings! Perhaps these men should not be criticized too severely; to them the matter of transmission loss was of no consequence and besides, they had no way of knowing how tight the belt should be.

And gears—old as the subject is—we all have much to learn about their proper use. Too frequently a gear is just a gear and has to run some way or break, so why worry about it? It must be admitted that the prob-

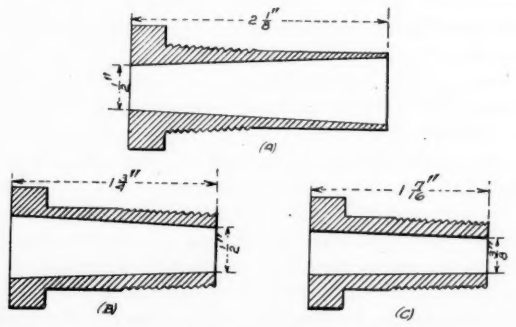
ability of power loss in a pair of gears is less than in most forms of transmission, yet even with gears there is often chance for improvement.

I do not mean to suggest that one should spend time puttering or tinkering with machinery in an effort to correct trivial things. An engineer once received the nickname "Monkey" because he always carried a monkey wrench in one hand and a hammer and chisel in the other. He never got very far either, because he overlooked the main trouble in his effort to find the little difficulties; but the proper installation, operation and care of transmission machinery does not call for that kind of attention.

Lack of attention to such matters results directly in two general losses: First, greater wear, upkeep, more frequent renewal, shorter life; second, power loss. Every shaft out of alinement means unnecessary power consumed. Every belt not properly installed means power loss in transmission. Every bearing not adjusted and lubricated means loss of power in friction. Every pair of gears not carefully alined and pitched means low efficiency. Power used necessitates power to be generated and unnecessary use of power in losses by transmission means waste of power. This may be seen in the dwindling of the company coal pile or in the monthly power bill. In any event, it is a waste and much of it can be avoided. R. S. H.

Fusible, or Safety Plugs

COMMENTING on the article of Receiver, entitled "Fusible, or Safety Plugs," page 331 of the April 15 issue: I do not write this as a criticism of Receiver, because in a good many states his article would apply; but in Massachusetts, if fireman or engineer should use it as a reference, they would be way off the right track. I will try therefore to make clear some points Receiver left out or did not consider.



TYPES OF FUSIBLE PLUGS USED IN MASSACHUSETTS

In the first place, he gives only two kinds of plugs—the inside and outside types of short plugs. This short outside plug cannot be used here.

There are three kinds of fusible plugs: the long outside at A, the long inside at B and the short inside at C. The long outside plug is used in practically all boilers except the vertical fire-tube type. This plug is from 2½ to 2¾ in. long and from ½ to 1½ in. in diameter. The long inside plug is from 1¾ to 2 5/16 in. long and ½ to 1½ in. in diameter; it is designed to be used in boilers where it was difficult to put in the outside plug. With the inside type, of course the hole in head or shell has to be tapped from the inside. The object of the long plug is that they project inside the boiler enough so there is not much danger of their being scaled over; also, they provide more area for contact with the water so as to conduct away the heat. On all boilers except the fire-tube vertical the plug must project inside not less than 1 in.

The short inside plug is from 1 7/16 to 1½ in. long and from ⅜ to ½ in. in diameter and is placed in an extra heavy tube (3/16 in.) in vertical fire-tube boilers not less than one-third the length of the tube from lower tubes sheet; the small end of fusible metal is ⅜ in.

All plugs have to be renewed every year.

W. N. L.

A Homemade Pump Governor

IN THE PLANT where I am employed we have a Worthington receiver pump set for feeding the boiler. One morning recently the pump refused to start when the receiver filled up and upon investigation I found that the governor casing had broken off where it screwed into the receiver shell. I found that I could not get a new valve for several days, so I decided to make one.

Taking a ½-in. globe valve, I filed the threads off the stem and slotted the end to take the lever, A. A fulcrum piece was made of a brass strip bent around the neck of the valve, just below the packing nut and soldered into place, as shown at B. The opposite end of lever A was connected to the float rod by a loose link, C. This lever may be placed at any angle with the body

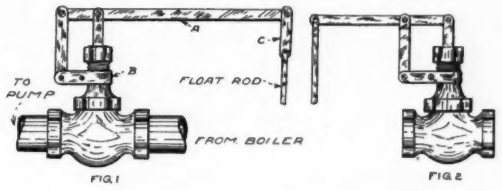


FIG. 1. GOVERNOR FOR RECEIVER PUMP
FIG. 2. WATER LEVEL REGULATOR

of the valve by loosening the union nut on the bonnet. In this case, I had to place it at a right angle. I find that it works best with the valve so placed that the pressure is under the disc.

When this rig was put to work, it gave perfect satisfaction and worked even better than the original governor, which had a tendency to stick quite frequently. By reversing the position of the fulcrum and valve stem as shown in Fig. 2, this governor could be used to keep a constant water lever in a tank, provided the steam line to pump could be brought into proper position so that the valve and float could be connected.

J. W. ESHNAUR.

Pressure for Veneer Driers

AS I READ the letter of the chief, bearing the caption, "Unusual Use of Vacuum Pump," and as published on page 296 of the April 1 issue, an experience I recently

had with the veneer drying equipment was brought to my mind. The two driers we have were formerly heated by exhaust steam at a pressure of 2 lb. with the condensate returned to the vacuum system.

One day, while looking over the specifications of these driers, I found that they had originally been designed and built for high-pressure service, and, being desirous of determining whether the use of high-pressure steam might hasten the process or effect any material saving, I made the change. However, due to the high degree of heat, it was found that the veneer was dried too quickly; but still feeling that the carrying of a steam pressure greater than 2 lb. was bound to result in some advantage. I reduced the pressure to 15 lb. by means of a Davis reducing valve, the returns as before being drained to the vacuum system.

As a result, I have found it to require 1½ hr. to do the work with exhaust steam, 30 to 40 min. with the steam at 15 lb. pressure and 20 min. with the steam at 100 lb.

The 30 to 40 min. rate being the most desirable for our purpose, I have since conducting this experiment, maintained a pressure in the driers of 15 lb.

W. C. FUNK.

Repairing Pump Valve and Water Level Regulator

THE HOLE in the valve disc of one of our pumps became worn so badly that the disc wore the guard unevenly and caused a continual knocking. I bushed the hole in the disc with a ¾-in. brass pipe which fits the guard nicely, gives the disc a sort of hub and causes it to seat truly. To prevent chatter and shock in the valve disc, the under side of the disc is faced with

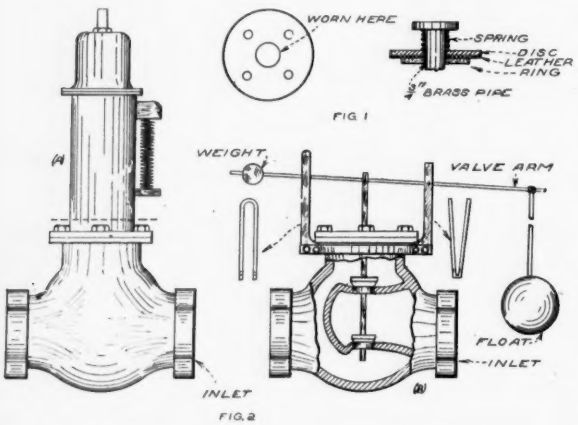


FIG. 1. DETAILS OF PUMP VALVE

FIG. 2. FLOAT REGULATING VALVE MADE FROM PRESSURE REDUCING VALVE

leather and a brass wearing ring riveted to the disc beneath the leather.

I had been having a great deal of trouble with a 1¼-in. float regulator which controlled the supply of water to a water heater; in fact, it was worn out and new regulators did not seem to last very long. We had a 2-in. pressure regulator in stock for which we had no immediate use, so I used it to make a float controlled valve.

At A, Fig. 2, is shown an exterior view of the pressure regulator. I cut the upper part off at the dotted line, the valve stem being left a little longer, and fitted with a forked joint and pin.

A band of ⅛-in. sheet iron is clamped around the upper part of the valve body to hold the support and guide for the float lever. The details of this job will be understood from the drawing, Fig. 2.

L. T. MCCOY.

Injured Men in Power Plants

I NOTE in a recent issue an article about using crippled men in a power plant. Three years ago I was in Lambertville, N. J. One Sunday, I took a walk to see the sights of that little town and ended up in a stone quarry. Here I saw a one-armed fireman. He surely did good work. He wheeled all his own coal and ashes. His left arm is off. He has a leather strap on the left handle of the wheelbarrow; this strap goes over his head and across his right shoulder. He fired with a long-handled shovel. By putting the handle up under his arm pit he was able to do a very good job. I had a curiosity to see him clean a fire, but did not have the opportunity.

R. G. SUMMERS.

Power for Excitation

THE AUTHOR of the article, "Power Required for Excitation," appearing in the April 1 issue, left an opening for a reply when he acknowledged that he was not satisfied with the answer the engine people gave him, and he showed his good judgment by not accepting it.

He was exactly right in the statement that the second card shows the horsepower required for excitation, but this was not a frictional load. The friction and windage load showed in the first card before the voltage was built up. The building up of the voltage could in no way affect the frictional load.

You know your machine was generating or you would have had no voltage, and the transforming of mechanical energy into electrical energy requires power in proportion to the amount of transformation. This was the power you found in your second card.

Now as to why you could not read this on your instruments: The current that built up the generator voltage was passing around the shunt windings of the machine. This current is what is known as the internal load and is seldom recorded on the board of a direct-current installation.

Your voltmeter read because it was across the main leads on the generator side of the switch.

The ammeter did not read because it was in series with the main line and there was no circuit on the main line until the switch was closed. The ammeter was not in the exciting circuit, it was in the line circuit.

This will be more easily seen in the alternating current plant of which you wrote.

Had your plant been arranged for parallel operation, you would have had a direct-current voltmeter and a direct-current ammeter in the exciter circuit, as well as

an alternating-current voltmeter and alternating-current ammeter in the generator circuit.

Now, when you build up the voltage on the alternating-current machine you will see the load build up on your exciter. The generator field is the exciter's load just the same as the lamps and motors are the generator's load.

With the generator up to voltage and the switch open, it is doing no work because there is no circuit. The exciter is, however, carrying about ¼ load.

The power required for excitation is proportional to the load carried on the generator, thus when the load is put on the generator the excitation must be increased or your alternating current voltage will drop.

This power could be computed from the board as follows:

d.c. amp. × d.c. v. ÷ 746 = hp. required for excitation.

The difference between this horsepower and the horsepower secured from the card with the generator up to voltage would give you the horsepower lost in friction on your generator, exciter and the belt driving them.

R. M. EDWARDS.

Calculating Tank Capacity

I WISH to call to the attention of the readers of Power Plant Engineering the fact that the solution of the problem bearing the above caption, published in the April 1 issue, is somewhat in error. While the answer is nearly correct, the method employed is wrong and had there been a greater difference between top and bottom areas the error would have been greater.

Below are given three correct methods.

The volume in cubic feet may be obtained by multiplying the product of 3.1416 by the height in inches, by the sum of the square of the top diameter in feet, the product of the top and bottom diameters (each in feet), and the square of the bottom diameter, also in feet.

By means of this rule, we obtain a volume of 1143.54 cu. ft.

The second method is that known as the Trapezoidal Rule. Take 1/6 of the height in feet and multiply by the sum of the area of the top, four times the area of the section midway between top and bottom, and the area of the bottom, each expressed in square feet.

The result will be, as before, 1143.54 cu. ft.

We may also solve this problem by considering the tank the frustum of a cone having a height of 72 ft. As the volume of a cone is equal to ⅓ the height times the area of the base, the volume of this cone would be equal to the product of ⅓ of 72, and 0.7854 times the square of 12, or 2714.34 cu. ft. The volume of the cone above the tank would be equal to the product of ⅓ the difference between 72 and 12, and 0.7854 times the square of 10, or 1570.80 cu. ft. The volume of the tank then would be equal to the difference between the volumes of these cones, or 2714.34 minus 1570.80, or 1143.54 cu. ft.

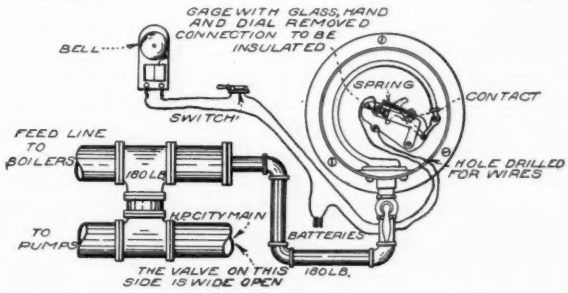
As will be seen, the first solution involves the least amount of calculation, but the third solution is the easiest to understand. The second method is given as a comparison to the one published, showing that instead of multiplying the height by the area at the middle, the height should be multiplied by 1/6 the sum of the areas at top, bottom and four times that at the middle.

M. L. MOSHER.

[In presenting solutions to problems, it is the general policy of the editorial department to employ the simplest processes consistent with a degree of accuracy equivalent to that of the measurements usually taken, and it is due to this fact that more elaborate formulas were not employed. It will be noted in checking up the solutions to this problem and comparing results, that the difference is but 0.27 of 1 per cent, a negligible quantity for all practical purposes. Inspection of the particular problem and experience in solving numerous others of like character suggested the method given as that most practical to employ.—Editor.]

A Pressure Signaling Device

SHOWN in the accompanying sketch is an alarm system I devised for use in connection with the feed line supplying our boilers with water. When the heating season is over, we shut down our pumps and use city pressure at 180 lb. gage for feeding our boilers. The only way to ascertain whether the boilers are being properly fed is by means of the water level gage glass, as there is not even a pressure gage on the line, and as in a one-man plant the operator is apt to depend too much upon a steady feed, some form of signaling device which will appraise him of any irregularities is almost a necessity.

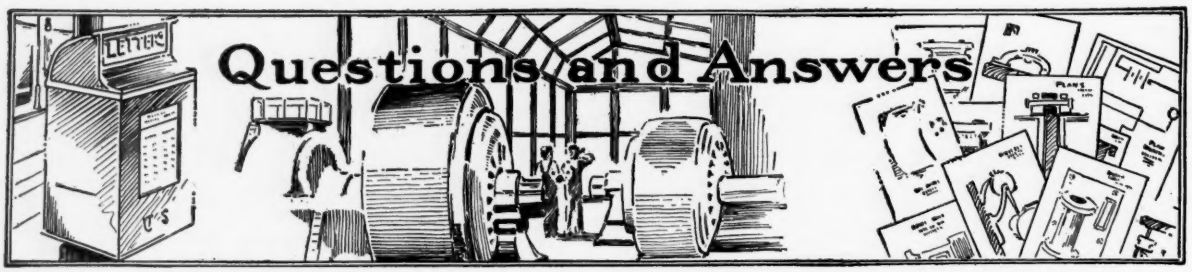


SCHEME OF CONNECTIONS EMPLOYED FOR SIGNALING DEVICE

Securing a spring, one which would form a good contact and still be not so stiff as to prevent the hand reaching zero under no pressure conditions, I attached this as illustrated with one end fastened under a screw head and well insulated, while the other end made contact with the ratchet lever. The connecting wires were passed through a hole drilled in the casing.

When the pressure falls below 170 lb., the circuit is closed and the alarm bell is caused to ring. Change of signaling pressure is accomplished by bending the spring slightly one way or the other. JOHN J. DINNEEN.

THE UNITED STATES now leads the world in the production of ferro-manganese. During the last fiscal year, it imported 656,088 gross tons of manganese ore, more than Great Britain ever imported, and had a domestic production of around 80,000 tons. This means a production of 270,000 tons of ferro-manganese in the current year. While it is estimated that 336,000 tons are needed, the shortage can be made up by importations and by a more efficient use of spiegeleisen.



Effect of Added Capacity on Coal Consumption

I WOULD LIKE a little information in regard to the steam consumption of our turbine.

If our output is 250 kw. and we add 200 kw. more, how much more coal would we burn?

Our turbine is an Allis-Chalmers of Parson reaction type and is a 750-kw. machine. Our steam guarantee is as follows:

At ½ load (375 kw.), 20.7 lb. per kw.-hr.

At ¾ load (562.5 kw.), 18.5 lb. per kw.-hr.

At full load (750 kw.), 17.4 lb. per kw.-hr.

Our coal burned and our kilowatt-hour output for the months of December, January, February and March was as follows:

Month	Coal burned, tons	Kw.-hr. generated
December	314	181,000
January	309	175,000
February	281	171,000
March	320	202,000

As the plant is a new one and in operation since July, we are not equipped with any recording instruments and have no way of weighing the coal except in carload lots, and we are therefore very much handicapped. J. F. W.

A. Of course, any calculation we make is somewhat approximate, but we are glad to give you the best idea that we can as to the effect of increasing the output of your plant on coal consumption.

Taking your records of coal burned and kilowatt-hours output for December, you used 3.49 lb. of coal per kilowatt-hour; for January, 3.53; for February, 3.21, and for March, 3.16, which is a good average range and shows that latterly you have been getting better results than in the earlier part of the winter, although, as this is carload lot weight there is some doubt as to the accuracy of the figures.

Taking the steam consumption as given in the makers' guarantees for the turbine, and plotting a curve, we find, approximately, that at 250 kw. output, you would be using about 25 lb. of steam per kilowatt-hour; at 450 kw. output, you would be getting about 19.5 lb. of steam per kilowatt-hour.

You will, therefore, by putting on the added load, be running your turbine unit at a much more economical point and, in this way, cutting down the steam used for the original 250 kw., in the ratio of 19.5 to 25; but, of course, you will be increasing the steam used in the ratio of 450 to 250. Taking these two ratios multiplied together, it gives 1.41 as the total ratio of steam used running at 450 kw. as compared with the steam for 250 kw.

Just how this would react on the coal pile would be a little difficult to say, as it would depend on how the capacity of your boilers is related to the capacity of the turbines. If the boilers are running at a low load at the present time, unquestionably you will improve the efficiency by adding somewhat to the load, you would be running with a hotter furnace, your loss from bank fires and rattling through the grate will be less in proportion, and you will get better combustion.

On the other hand, if your boilers are loaded about normal at the present time, and you should try to force them up to nearly double their rated capacity—unless they are large boilers, specially built for this kind of service—the chances are that the efficiency will be lessened.

Feeding Shavings to Furnaces

WITH THE prevailing high prices of coal, we have been driven to seek economy in fuel consumption in some way or another.

We have considerable waste kiln-dried wood which we have been selling, but which we figure can be utilized to much greater advantage if we turn the wood into shavings through a kindling hog and store the shavings, to be fed through a separate blower outfit to the furnace as needed.

This idea was submitted to a blower company with the supposition that they would comment one way or another on the idea we had in mind. They were told that we intended to store the shavings and feed them to the furnace through a blower from the vault. They made us a quotation on an equipment they said would take care of our requirements. Yesterday we had a representative of a cyclone concern here to check up our dust collecting system, and to replace our old cyclone with one that will take care of conditions and also of the kindling hog, if we put one in. That representative told us that it would be ridiculous to try to feed shavings direct through a blower into the furnace. He states the flues and fire grates would go to pieces in no time. A solution he suggested was that we hook the factory hog direct to the main cyclone and feed all shavings gathered in the factory and made in the hog directly through the cyclone into the furnace.

That is the way we are at present handling the dust collecting system. If we install a kindling hog it would not be economical to have a man standing at the machine all day long and feed kindling just fast enough to get the most fuel value out of the wood. The machine we intend to put in would make a ton of shavings an hour. We will gather just about a ton of waste material a day. If we tried to force a ton of shavings through the furnace in 1 or 1½ hr. our fireman would have to be standing at the furnace door to keep the shavings from killing his fire. That proposition cannot be enter-

tained. What we want to find out is whether there is some practical method in use that is not too cumbersome which stores shavings in a vault and feeds those shavings as required, to furnaces. If we can get an idea for some practical system of that kind we can effect a great saving in the coal used, which will be saving us some money and assist in relieving railroad troubles.

Can readers give us some information in regard to this matter? D. J. B.

Stress in Spiral Springs

WILL YOU please tell me how to determine the tension in large springs such as in clocks or phonographs, but much larger? L. E. B.

A. There seems to be little information in regard to the stress in a spiral spring such as you mention. The only matter we can find is the formulas given by Reuleaux, as follows:

$$P = \frac{S\,b\,h^2}{6\,R}$$

in which P is the force applied at a distance R from the center;

S is the stress, taken as 4/5 of the allowable stress in flexure;

b is the breadth;

h is the thickness, in inches.

For this formula, S would equal $\frac{6\,P\,R}{b\,h^2}$. To give the deflection at the end of the spring,

$$f = 12\,\frac{P\,l\,R^2}{E\,b\,h^3}$$

where f is the deflection, and E the modulus of elasticity taken as 30,000,000 for steel, and l is the developed length of the spiral.

For the case of a spring which is being wound up, f is, of course, the distance R times the angle in radius.

The angle of rotation, f ÷ R, would be equal to

$$\frac{f}{R} = \frac{2\,S\,l}{E\,h}$$

and from this equation we would have, $S = \frac{f\,E\,h}{2\,l\,R}$.

Steam Heating System for School Building

WE CONTEMPLATE changing the heating system of a four-room school building from hot air to steam; the dimensions of each room are approximately 28 by 32 by 10 ft.

Will you kindly inform me as to the required number of square feet of radiation and size of boiler?

D. A. O.

A. In your school building, the amount of radiation needed in each room will be about 128 sq. ft. This may be supplied either in pipe coils or in cast-iron radiators. If the latter is used, it would require, say, four radiators of the two-column type, 26 in. high, in 14 sections, or about 35 in. long. It would be better to have more, rather than less, surface. The radiators should be set, so far as possible, underneath the windows.

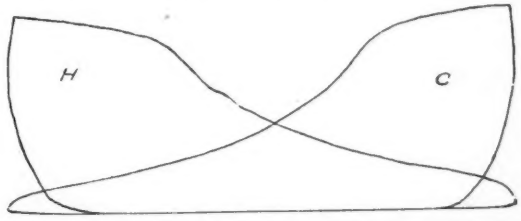
For a plant of this size, the one pipe system will be satisfactory, and this would require a 2-in. supply pipe to each room, with a 1-in. connection to each radiator. It will probably arrange better to use two mains, each 3 in. in diameter, and each supplying two rooms. These mains should be installed with a drop of 1 in. in 10 ft. towards the boiler, so that the condensed steam can drain back properly.

A cast-iron sectional boiler should be used, with capacity to supply 650 sq. ft. of radiating surface. This should have a safety plug in the section over the furnace, extending 1 in. inside the boiler. It should be supplied with steam gage, pop safety valve, water gage glass, and gage cocks. It should have returns from the radiators entering the boiler near the bottom, with a check valve to prevent the water being forced back into the returns. There should be, also, a blowoff valve, and a water supply pipe. The water can be supplied from the city mains.

The mains in the basement should be covered with insulating material to prevent the waste of heat in the basement. For a plant of this size, this covers practically the requirements of the installation.

Indicator Card for Criticism

THE INDICATOR card shown herewith was taken from a 20 by 36-in. engine running at a speed of 145 r.p.m.



WHAT IS WRONG WITH THIS CARD?

Will some of the readers kindly criticize this card and tell me what is wrong and how I may make the necessary adjustments? A. G. E.

Engine Balancing

IN A HORIZONTAL ENGINE, 14 by 20 in., at 230 r.p.m., there is considerable vibration. The foundation is not in very good condition, but it is impossible to shut down to change the foundation.

What suggestions can readers make as to a method of balancing the engine, or overcoming the vibration, without shutting down longer than for the night period and without dismantling the engine?

Question for Readers

A SUBSCRIBER would like to know at what temperature lard boils. This information does not seem to be available in any of the engineering data, but perhaps some reader in a packing house plant can give the information.

Cost of Operating Oil Engine Plants

AS OUR STEAM PLANT is just about ready to be discarded, we are considering the installation of oil engines. Before making the change I would, however, like to hear from somebody who has substituted oil for steam, relative to the comparative operation costs. A. L. B.

POWER PLANT ENGINEERING

Trade-mark, Reg. U. S. Pat. Off.

(Established over 22 years.)

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Close 'Em All Up

Following the logic of those Members of Congress who object to the carrying of periodicals by the Post Office unless the full cost of carriage is paid by the subscriber, let us see what the government should stop doing. No work should be done by the government, according to their idea, unless those benefited pay the whole cost plus a profit.

First: Close all public schools, colleges and universities that are receiving federal or state aid. Not one of the students pays the cost of teaching him. Future value of his training to the country ought not to be considered, as long as his tuition doesn't pay the cost of it.

Second: Shut up all experiment stations. Not one of them raises enough crops or collects enough fees to come anywhere near paying the expense of operating. The benefit to farmers and manufacturers is not a concern of the government.

Third: Call home all representatives of the various departments who are engaged in fostering foreign trade. The exporters are paying nothing to offset this expense and the government should be a means for helping private commerce.

Fourth: Send out no more government publications unless the cost is paid in full by the one receiving them. The government printing office is a tremendously expensive establishment, and the cost of the Post Office for carrying these publications is huge.

Fifth: Abolish all rural free delivery routes. Not one of them brings in income from mail sent and received sufficient to pay for maintaining the service.

Sixth: Make all mail pay according to the distance it is carried, whether letters, circulars, or photographs. If Jones in Arizona wants to send a letter to New York he ought to pay five times as much as Smith who lives in Buffalo. That's a penalty that should be imposed on him for living so far from the big city. And Congress man Green, of Nevada, ought to pay eight times as much when he writes to his friends at home as does Congressman White, of Delaware. The government should charge for mail according to the cost. Convenience of the public and binding all parts of the country together into a nation by giving national service ought not to be considered.

That is what the logic of the zone system, applied to periodicals by the amendment to the revenue bill passed by the last Congress, amounts to. Service to the country and to the people is to be left out of the question. Everybody must pay according to the distance his magazine is carried to him.

How does the prospect look?

Is it a good principle to follow in government work? If it is, let's go at it and "close 'em all up" unless each person served by any government department pays enough to cover the cost of that service plus a profit.

If you don't like this method, write *your* Congressman and tell him you want that zone system amendment repealed.

Unless it is repealed, the postage on periodicals will be increased from 50 to 900 per cent; and subscribers must pay it, for the increase is more, in almost every case, than the entire profit that the publisher has been making.

Last year, the Post Office showed a profit of $9,000,000 on all departments. No other department is expected to show a profit, or even to pay expenses. If the only part of the Post Office activity which can be classed as educational is to be put on the basis of paying its way, all other government service should be treated likewise.

But, if you believe that it is a proper part of governmental activity to foster the education of the people in industries, in morals, in religion, in loyalty, let your representatives at Washington, Congressmen and Senators, know, in no uncertain terms, that you want the service of the magazines and business papers enlarged rather than destroyed; that you believe in national rather than sectional activity, and that you wish them to work and vote for the repeal of the amendment that imposes the zone system on our greatest educational force. Write today.

Americans for America

In a recent address, Secretary Lane stated that there are in this country five and a half millions of people who cannot read or write English, the language of this country; and a million and a half are native born.

In many plants, instructions must be given, or orders issued, in a foreign language to avoid mistakes which will cause serious loss of material and life. The question comes up sharply: Can a man or a woman who does not understand the language of America be a real American?

Every man who has any authority or influence over others has a responsibility and a privilege in this matter. It is a misfortune for every man who permanently resides in the United States if he is not a citizen. Not only is his loyalty open to question, but he can have no part in determining the government under which he lives, and he can claim little share in the success of the struggle for liberty in which we are now engaged.

Nobody can be in touch with the spirit of this land unless he can understand addresses delivered in English or can read the papers and periodicals printed in English. Hence, our privilege as well as duty to assist in bringing those who do not possess it to the full dignity of citizens and Americans.

Aside from this, the gain in mental ability and alertness by studying to learn English has proved in most cases to be worth while in improving a man's efficiency as a workman. And the habit of studying once acquired, and the mind awakened, study usually goes on with increasing effectiveness.

In manufacturing plants it is found to pay as a business proposition to teach the employes English, and incidentally the history, science and art of their work in periods taken from the working hours. It is probable that the same might be found true with the power plant force. But whether a dollars-and-cents return be found or not, the responsibility of the chief engineer for seeing to it that every man in his force is encouraged to be a full citizen with all the privileges, duties and loyalty of a real American cannot be evaded. And this opportunity should be regarded as a privilege to assist the country in outgrowing the condition of unassimilated groups and individuals which now form a menace to our peace and effectiveness.

Americans for America is our need and should be our goal.

Oil as Boiler Fuel

HIGH price and difficulty of getting coal have turned the attention of engineers to fuel oil as a source of heat for boilers, and in some plants the substitution has been found to work to advantage. As the control of the supply of fuel oil is now in the hands of the Fuel Administration, there is no certainty that oil will be subject to less restrictions than coal for power plant use; but the advantages of cleanliness, flexibility and efficiency are in its favor, and as the limit of demand on the oil industry is now the call for gasoline, the supply of fuel oil or distillate is likely to be limited more by transportation facilities than by flow from the wells.

The oil available has a heat value of about 18,400 B.t.u. per lb., so that 1600 lb. or 4.5 bbl. will be the equivalent of a ton of New River coal. Data given by the Electrical World show what is being accomplished by the substitution.

Oil comes largely from the Mexican or southern United States wells by ships to the ports, and is distributed by tank trucks or cars at a price of from 4 to 5 cents a gallon. One truck will deliver in a day the equivalent of 100 T. of coal.

With oil, one fireman can handle 10 to 15 boilers, and can leave a boiler without fire until shortly before it is needed to supply steam. Whereas, with coal, a 200-hp. h.r.t. boiler will use some 3000 lb. of coal weekly for banking fires. Comparative tests on two 140-hp. h.r.t. boilers, under like conditions showed an evaporation from and at 212 deg. F. at a load of 285 hp. of 15.55 lb. water per pound of oil and efficiency of 80 per cent, while for coal the evaporation at a load of 202 hp. was 10.3 lb. water per pound of coal and the efficiency 68 per cent.

Capacity is increased, as the chimney area needed for oil fuel is only 50 per cent that needed for coal. In a 1700-hp. boiler plant, the steam capacity was increased 40 to 70 per cent, $2100 a year saved on labor, $600 on ashes removal, and about $6000 on fuel, and increase of efficiency from 66.6 per cent with coal to 81.5 per cent with oil.

For plants up to 125 hp., the rotary burner of the Fess system has been frequently used, oil being forced into the burner at 15 lb. pressure by a pump requiring ⅛ to ¾ hp., according to conditions. For larger plants, the fixed burner and steam-jet atomization is used. In the former case, the oil is warmed by steam coils between the storage tank and the pump; in the latter case, by steam coils in the main storage tank.

Another Cut in French Rations

WE SEE in the papers that France is not hungry; that all one needs is money with which to buy a liberal meal. Perhaps it is true that some people in France, as in the rest of the world, with a full pocketbook can obtain an unfair share of food. But that France as a whole has enough food is unfortunately very far from true. We need only note that a still further reduction in bread rations was made early in April. These rations had already been cut to almost half the normal consumption. By the recent restriction, a further cut of ⅓ is made. The hard worker now receives only the amount granted to the desk worker a month ago.

"John Crane" Metallic Packing

"JOHN CRANE" packing was invented by an operating engineer named John Crane in the early spring of 1912. John Crane then had charge of a large power plant and was directly responsible for maintenance and repair costs.

His first object was to develop a permanent packing; and, of course, he desired to reduce the bills to the very minimum, but, if possible, to make his packing permanent.

Flexibility and compressibility were also desirable, necessitating some mechanical combination. Of course, it was possible to take metal and shred it and twist it in the form of rope, or braid it in the form of packing. This would give the flexibility. But would it be a packing through which pressure could not pierce? After much thought and experimentation, John Crane evolved the idea of taking a long, thin, continuous strip of metal foil and wrapping it spirally round and round, back and forth, operating each two sheets with a layer of lubricant to permit the sheets to slide on each other and to allow bending about the smallest diameter and giving a compressibility sufficient to compensate for wear and to control any ordinary pressure. These spirally wrapped sheets, he found, formed perfect barriers through which pressure could not pierce and gave a strong, durable construction.

MANUFACTURE OF "JOHN CRANE" PACKING

The idea of simplicity did not get away from John Crane. He had packed many stuffing boxes in his day and knew that a packing which would be a success must be simple to install, one that could be installed in the same stuffing boxes as soft packings and with equal ease. He therefore used soft metal which could be cut with a knife, took any form or shape under pressure of the gland and bent about the plunger easily. These features, he knew, would appeal to every experienced engineer. Reduction of rod friction and elimination of wear were also prominently borne in mind when this packing was developed. That is why he selected the best antifrictional metallic sheet combination with babbit alloy he could find. A mechanical construction of these sheets spirally wrapped, with reservoirs of lubrication between each two sheets was successful in eliminating the wear on the rod.

Thus was John Crane's ambition realized. "John Crane" products are now made up in all kinds of forms. The line has been steadily developing and today any combination of metal alloys for special services can be secured, either in form of a packing or in a gasket.

Nicholson Expansion Trap

DEPENDING upon the difference in expansion of two metals due to changes in temperature, the Nicholson expansion steam trap is positive in its action and as reliable as the effects of heat. When used in connection with heating coils, the trap is so regulated that when turning on steam in the heating system, the valve is wide open and remains open until all air and water are blown out. As steam enters the trap its heat expands the center tube to which is attached the valve seat and carries it up to the valve, thus closing the trap. Later as condensate collects in the body of the trap it lowers the temperature of the center tube and causes it to contract, drawing the seat away from the valve and permitting the water to flow out under the pressure in the coils.

SECTIONAL VIEW OF THE NICHOLSON EXPANSION STEAM TRAP

The trap will operate in any position and is adjusted while heated by steam passing through the valve for the moment by gradually screwing the outlet connection back on the trap body until steam is entirely shut off. Then the lock nut is set up to maintain the adjustment.

This trap is the product of W. H. Nicholson & Co., Wilkes-Barre, Pa.

Worthington Corporation Elects President

THE recent election of Charles Philip Coleman as president of the Worthington Pump and Machinery Corporation calls attention to this large industrial enterprise and to the new executive, who has had an experience which exceptionally fits him for the position.

Mr. Coleman advances from the position of vice-president, held since May, 1916, to the presidency. He was, prior to that date, receiver of the International Steam Pump Co. and associate companies, which have now been reorganized into the present corporation, which owns and controls some of the best equipped works in the country and is the leading interest of the world in pumping machinery and affiliated lines.

Mr. Coleman was born in Baltimore, both branches of his family dating back to English colonists who settled in this country during colonial times. His education was begun in Baltimore and continued at the Virginia Military Institute and the Shenandoah Valley Academy at Winchester. Later he entered Lehigh University, from which he graduated with the degree of M.E. After leaving the university he entered the employ of the Lehigh Valley Railroad Co. and continued with that company in the various positions of car agent, chemist, engineer of tests, assistant to general superintendent and general storekeeper, until 1903, having left the Lehigh for two years during this time to serve the Bethlehem Steel Co. as purchasing agent and assistant to the president. Later he was made general purchasing agent of the Lehigh, with headquarters in New York.

In 1903 the Singer Sewing Machine Co. made Mr. Coleman its secretary and treasurer, and during his incumbency of this position he had charge of the construction of the Singer Building, which was at that time a most important and unusual undertaking and remains one of the most conspicuous buildings in New York City.

After leaving the Singer Co., Mr. Coleman became president of the Saurer Motor Co. and afterward of the International Motor Co. He came to the International Steam Pump Co. in 1913 as vice-president, and upon the outbreak of the war in 1914 was made one of the co-receivers of the company, which had been compelled to go into the federal courts because of its financial difficulties, brought about by the war conditions.

Mr. Coleman became sole receiver of the company in 1915, due to resignation of the other receiver, Mr. Grayson M. P. Murphy, and handled its affairs until reorganization in 1916 and in so satisfactory a manner as to secure the warm commendation of the United States Court. After the reorganization into the present Worthington Pump and Machinery Corporation, the vice-presidency was again given Mr. Coleman, and he continued in that position until his recent election as president.

Mr. Coleman is married and has two sons. His wife was Miss Helen Douglas Rulison, a daughter of the Rt. Rev. Nelson S. Rulison, Episcopal Bishop of Central Pennsylvania. The sons are both serving in the United States Army at present, one as captain, Third U. S. Field Artillery, and the other as lieutenant, Aviation Section of Signal Corps.

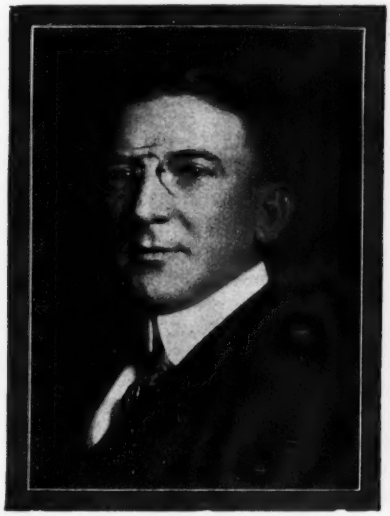
The Worthington Pump and Machinery Corporation, of which Mr. Coleman has just become president, has been and is now very active in its service to the government, covering large and important lines of product. The corporation, with its eight large works in this country and a European works, is in an unusually good position to be of great assistance to both the United States and its allies, and the equipment and size of its various works have permitted of taking on responsibilities amounting to millions for war work, and yet handle its heavily increased regular business satisfactorily.

While the principal business of the corporation is pumping machinery in all its varied types and developments, yet the capacity of its shops is such that the war work above referred to has been handled in most satisfactory shape and still other and promising lines of regular manufacture added.

The standard products, aside from pumping machinery, cover mining and concentrating machinery, oil and gas engines, air compressors, gas power engines and blowers, crushing and cement equipment, waterworks engines and special machinery.

The number of works now operated in the United States by the corporation is eight, as follows:

1. The great Worthington Works at Harrison, N. J., devoted exclusively to the manufacture of pumping machinery.
2. The Blake & Knowles Works at East Cambridge, Mass., now entirely rebuilt and producing principally marine pumps.
3. The Deane Works at Holyoke, Mass., which manufactures power pumps only.
4. The Snow-Holly Works at Buffalo, N. Y., building the largest machines required in waterworks, blowing and gas power engines and oil engines.
5. The Power & Mining Machinery Works at Cudahy, Wis., which, as its name indicates, gets out a complete line of crushing, concentrating and mining equipment.



CHARLES PHILIP COLEMAN

6. The Laidlaw Works at Cincinnati, O., given over to air compressing machinery only.
7. The Jeanesville Works at Hazleton, Pa., working at present on special product.
8. The International Gas Engine Works at Cudahy, Wis., making a full line of gas and oil engines and accessories.

Loss of capacity in a refrigerator system may be due, according to E. W. Miller in Refrigerating World, to compressor leakage from a stuck or broken valve or a broken piston ring, to oil in the system, to frost on brine or expansion coils, to insufficient charge of ammonia, to defective suction gages, to poor brine circulation, to ice on the coils in the brine tank, or to deterioration of the ammonia due to a poor grade of oil or to brine or water leaking into the ammonia coils.

To call a man by name, at once, is the most subtle and appealing compliment in the world.

Priorities List for Coal Supply

THE United States Fuel Administration will be governed in the distribution of coal and coke by a list of priorities recently arranged by the War Industries Board. The board has listed certain industries for preference, whose operation is of exceptional importance, measured by the extent of their direct or indirect contribution either toward winning the war or toward promoting the national welfare. Not only will the industries coming under the new classification be given preferential treatment by the Fuel Administration but also in transportation by the railroads.

The following is the list of preferred industries:

Aircraft: Plants engaged exclusively in manufacturing aircraft or supplies and equipment.

Ammunition: Plants engaged in the manufacture of ammunition for the United States Government and the Allies.

Army and Navy cantonments and camps.

Arms (small): Plants engaged in manufacturing small arms for the United States Government and the Allies.

Chemicals: Plants engaged exclusively in manufacturing chemicals.

Coke plants.

Domestic consumers.

Electrical equipment: Plants manufacturing it.

Electrodes: Plants producing electrodes.

Explosives: Plants manufacturing explosives.

Farm implements: Manufacturers exclusively of agricultural implements and farm operating equipment.

Feed: Plants producing feed.

Ferro-alloys: Plants producing.

Fertilizers: Manufacturers of fertilizers.

Fire brick: Plants producing exclusively.

Food: Plants manufacturing, milling, preparing, refining, preserving, and wholesaling food for human consumption.

Food containers: Manufacturers of tin and glass containers and manufacturers exclusively of other food containers.

Gas: Gas producing plants.

Guns (large): Plants manufacturing them.

Hemp, jute and cotton bags: Plants manufacturing exclusively, hemp, jute and cotton bags.

Insecticides: Manufacturers exclusively of insecticides and fungicides.

Iron and steel: Blast furnaces and foundries.

Laundries.

Machine tools: Plants manufacturing machine tools.

Mines.

Mine tools and equipment: Plants engaged exclusively in manufacturing these:

Newspapers and periodicals: Plants printing and publishing exclusively newspapers and periodicals.

Oil: Refineries of both mineral and vegetable oils.

Oil production: Plants manufacturing exclusively oil well equipment.

Public institutions and buildings.

Public utilities.

Railways.

Railways: Plants manufacturing locomotives, freight cars and rails, and other plants engaged exclusively in manufacture of railway supplies.

Refrigeration: Refrigeration for food and exclusive ice-producing plants.

Seeds: Producers or wholesalers of seeds (except flower seeds).

Ships (bunker coal): Not including pleasure craft.

Ships: Plants engaged exclusively in building ships (not including pleasure craft) or in manufacturing exclusively supplies and equipment therefor.

Soap: Manufacturers of soap.

Steel: Steel plants and rolling mills.

Tanners: Tanning plants, save for patent leather.

Tanning extracts: Plants manufacturing tanning extracts.

Tin plate: Manufacturers of tin plate.

Twine (binder) and rope: Plants producing exclusively binder twine and rope.

Wire rope and rope wire: Manufacturers of these.

Automobile plants are not in the list.

News Notes

CONVENTION of the National Pipe and Supplies Assn. will be held at the Hollenden Hotel, Cleveland, O., May 13 and 14.

On May 15-17, the combined convention of the Southern Supply and Machinery Dealers' Assn., the American Supply and Machinery Mfrs.' Assn. and the National Supply and Machinery Dealers' Assn. will be held at the same place. Wednesday morning will be devoted to opening addresses by the presidents of the three associations, and the afternoon to separate executive sessions, to reports and to discussions on business problems of warehousing and selling. In the evening a smoker will be arranged for those in attendance.

On Thursday morning addresses will be delivered to a joint session on the business situation with regard to Rubber Goods, Transmission, Valves, Twist Drills, Leather Belting, Steel Products, Bolts, Engineering Specialties, Export and Domestic Trade. The joint meeting in the afternoon will take up Trade Acceptances and the Supply and Machinery Man's Part in Winning the War. A musical program will occupy the evening.

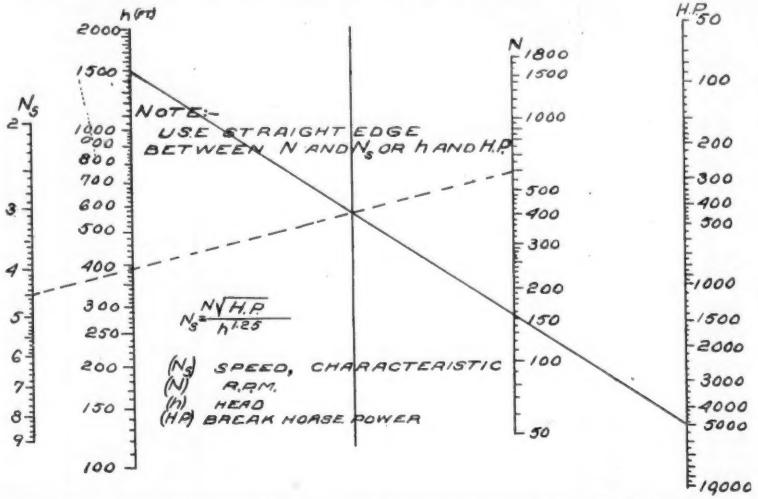
Friday morning executive sessions will be held with discussion on Overhead Expense, Federal Taxes, Methods of Compensating Salesmen, the Sales Executive, and Filling Gaps Left by Men Who Have Gone to War. The session will conclude with election of officers and selection of place for the next convention.

A TOTAL of $2,144,800 subscribed by employes is the record of a 10-day Liberty Loan campaign in the organization of the Westinghouse Electric and Mfg. Co. With 30,384 subscribers from the company's various plants and district offices, the "bogie" set for this and the total subscription figures was largely exceeded.

Mass meetings at the noon hour addressed by four-minute speakers recruited from the shop employes, were an important feature of the campaign. At one such meeting, held at East Pittsburgh works, several thousand people listened to Sousa's Band, and were addressed by Major Watt of the Gordon Highlanders. The Westinghouse and Scotch Kilties Bands played at other similar meetings.

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly will be sent you for 20

CHART SHOWING RELATION BETWEEN CHARACTERISTIC SPEED, REVOLUTIONS PER MINUTE, HEAD AND HORSE-POWER OF HYDRAULIC IMPULSE TURBINES

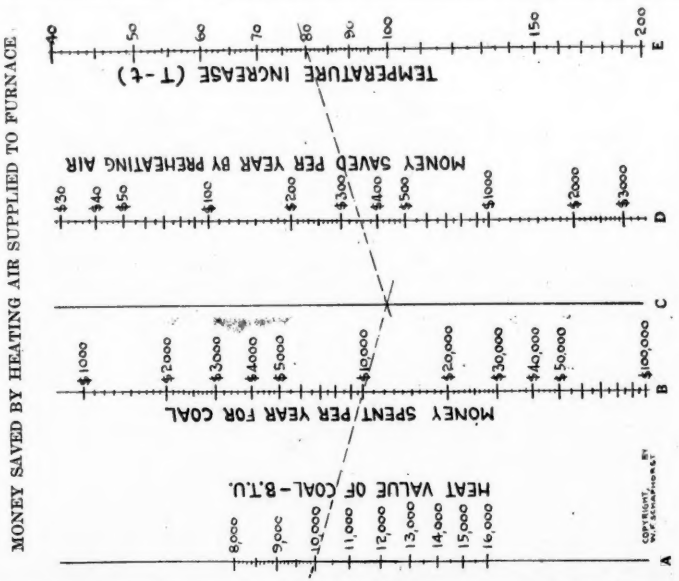

POWER PLANT ENGINEERING
NOTE:- USE STRAIGHT EDGE BETWEEN N AND N_s OR h AND H.P.
$N_s = \frac{N\sqrt{H.P.}}{h^{1.25}}$
(N_s) SPEED, CHARACTERISTIC
(N) R.P.M.
(h) HEAD
(H.P.) BRAKE HORSE POWER

COMPARATIVE COST OF COAL TO OPERATE VARIOUS TYPES OF ENGINES

Based on coal containing 12,000 B. T. U. per pound, 60 per cent Boiler efficiency, 100 pounds pressure, feedwater 150 degrees. We have assumed the basis of water consumption as constant for all powers, while in practice it should be somewhat less as the horsepower increases.

Indicated Horsepower	Type of Engine	Basis of Water Consumption in pounds	Coal at $1.25 per Gross Ton: 10-Hour Run Lbs. Used	Coal at $1.25 per Gross Ton: 10-Hour Run Cost	Cost 1 Year 300 Days	Coal at $1.50 per Gross Ton: 10-Hour Run Lbs. Used	Coal at $1.50 per Gross Ton: 10-Hour Run Cost	Cost 1 Year 300 Days
1	Throttling	48	71.75	$0.040	$12.00	71.75	$0.048	$14.42
	Automatic	33	50.00	.028	8.40	50.00	.034	10.05
	Four-Valve	28	42.00	.023	7.03	42.00	.028	8.44
	Corliss	25	37.50	.021	6.28	37.50	.025	7.54
50	Throttling	48	3587.00	2.000	600.00	3587.00	2.400	721.60
	Automatic	33	2500.00	1.400	420.00	2500.00	1.680	502.50
	Four-Valve	28	2100.00	1.170	351.50	2100.00	1.410	422.00
	Corliss	25	1875.00	1.050	314.00	1875.00	1.250	377.00
75	Throttling	48	5381.00	3.000	900.00	5381.00	3.600	1081.50
	Automatic	33	3750.00	2.100	630.00	3750.00	2.510	753.75
	Four-Valve	28	3150.00	1.760	527.25	3150.00	2.110	633.00
	Corliss	25	2813.00	1.570	471.00	2813.00	1.880	565.50
100	Throttling	48	7175.00	4.000	1200.00	7175.00	4.810	1442.00
	Automatic	33	5000.00	2.800	840.00	5000.00	3.350	1005.00
	Four-Valve	28	4200.00	2.340	703.00	4200.00	2.810	844.00
	Corliss	25	3750.00	2.100	628.00	3750.00	2.510	754.00
200	Throttling	48	14350.00	8.000	2400.00	14350.00	9.600	2884.00
	Automatic	33	10000.00	5.600	1680.00	10000.00	6.700	2010.00
	Four-Valve	28	8400.00	4.680	1406.00	8400.00	5.630	1688.00
	Corliss	25	7500.00	4.200	1256.00	7500.00	5.030	1508.00
350	Throttling	48	25112.00	14.000	4200.00	25112.00	16.820	5047.00
	Automatic	33	17500.00	9.800	2940.00	17500.00	11.730	3518.00
	Four-Valve	28	14700.00	8.190	2461.00	14700.00	9.850	2954.00
	Corliss	25	13125.00	7.330	2198.00	13125.00	8.800	2639.00
500	Throttling	48	35875.00	20.000	6000.00	35875.00	24.030	7210.00
	Automatic	33	25000.00	14.000	4200.00	25000.00	16.780	5025.00
	Four-Valve	28	21000.00	11.700	3515.00	21000.00	14.070	4220.00
	Corliss	25	18750.00	10.470	3140.00	18750.00	12.570	3770.00
800	Throttling	48	57400.00	32.000	9600.00	57400.00	38.450	11536.00
	Automatic	33	40000.00	22.400	6740.00	40000.00	26.800	8040.00
	Four-Valve	28	33600.00	18.750	5624.00	33600.00	22.510	6752.00
	Corliss	25	30000.00	16.750	5024.00	30000.00	20.110	6032.00

—Nagle Corliss Engine Works


POWER PLANT ENGINEERING
MONEY SAVED BY HEATING AIR SUPPLIED TO FURNACE
TEMPERATURE INCREASE (T - t)
MONEY SAVED PER YEAR BY PREHEATING AIR
MONEY SPENT PER YEAR FOR COAL
HEAT VALUE OF COAL - B.T.U.

APPROXIMATE STEAM OR WATER CONSUMPTION OF VARIOUS TYPES OF ENGINES

In Pounds per Indicated Horsepower per Hour—Non-Condensing

Horsepower of Engine	Automatic Engines: Simple Single-Valve 90 lbs. I. P.	Simple Single-Valve 110 lbs. I. P.	Simple Four-Valve 90 lbs. I. P.	Simple Four-Valve 110 lbs. I. P.
60	30 to 33	29 to 32	27 to 29	27 to 28
75	30 to 33	29 to 32	27 to 29	26 to 28
100	29 to 32	28 to 31	26 to 28	26 to 28
150	29 to 32	28 to 31	26 to 28	25 to 28
200	29 to 32	28 to 31	26 to 28	25 to 28
250	29 to 32	28 to 31	26 to 28	25 to 27
300	29 to 32	28 to 31	26 to 28	25 to 27
400	29 to 32	28 to 31	26 to 27	25 to 27
500	28 to 31	27 to 30	26 to 27	25 to 27
600	28 to 31	27 to 30	26 to 27	24 to 26
700	28 to 31	27 to 30	26 to 27	24 to 26
800	28 to 31	27 to 30	26 to 27	24 to 26

For pressures above 100 lbs., the approximate savings are:

Pressure	100	110	120	130	140	150	160
Saving Per Cent.	0	2	3.5	4.75	5.8	6.75	7.75

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

COAL COST TO OPERATE ENGINES

Indicated Horsepower	Type of Engine	Basis of Water Consumption in pounds	Coal at $1.75 per Gross Ton: 10-Hour Run Lbs. Used	10-Hour Run Cost	Cost 1 Year 300 Days	Coal at $2.00 per Gross Ton: 10-Hour Run Lbs. Used	10-Hour Run Cost	Cost 1 Year 300 Days
1	Throttling	48	71.75	$0.056	$16.79	71.75	$0.064	$19.16
	Automatic	33	50.00	.039	11.70	50.00	.045	13.35
	Four-Valve	28	42.00	.033	9.83	42.00	.037	11.21
	Corliss	25	37.50	.029	8.77	37.50	.033	10.01
50	Throttling	48	3587.00	2.800	839.50	3587.00	3.190	958.00
	Automatic	33	2500.00	1.950	585.00	2500.00	2.230	667.50
	Four-Valve	28	2100.00	1.640	491.50	2100.00	1.870	560.50
	Corliss	25	1875.00	1.460	438.50	1875.00	1.670	500.50
75	Throttling	48	5381.00	4.180	1259.25	5381.00	4.790	1437.00
	Automatic	33	3750.00	2.920	877.50	3750.00	3.340	1001.25
	Four-Valve	28	3150.00	2.460	737.25	3150.00	2.800	840.75
	Corliss	25	2813.00	2.190	657.75	2813.00	2.500	750.75
100	Throttling	48	7175.00	5.600	1679.00	7175.00	6.380	1916.00
	Automatic	33	5000.00	3.900	1170.00	5000.00	4.460	1335.00
	Four-Valve	28	4200.00	3.280	983.00	4200.00	3.740	1121.00
	Corliss	25	3750.00	2.930	877.00	3750.00	3.340	1001.00
200	Throttling	48	14350.00	11.200	3358.00	14350.00	12.770	3832.00
	Automatic	33	10000.00	7.800	2340.00	10000.00	8.900	2670.00
	Four-Valve	28	8400.00	6.560	1966.00	8400.00	7.440	2242.00
	Corliss	25	7500.00	5.850	1754.00	7500.00	6.670	2002.00
350	Throttling	48	25112.00	19.590	5876.00	25112.00	22.350	6706.00
	Automatic	33	17500.00	13.650	4095.00	17500.00	15.580	4673.00
	Four-Valve	28	14700.00	11.470	3440.00	14700.00	13.080	3924.00
	Corliss	25	13125.00	10.230	3069.00	13125.00	11.680	3504.00
500	Throttling	48	35875.00	27.980	8395.00	35875.00	31.930	9580.00
	Automatic	33	25000.00	19.500	5850.00	25000.00	22.250	6675.00
	Four-Valve	28	21000.00	16.380	4915.00	21000.00	18.680	5605.00
	Corliss	25	18750.00	14.620	4385.00	18750.00	16.680	5005.00
800	Throttling	48	57400.00	44.770	13432.00	57400.00	51.090	15328.00
	Automatic	33	40000.00	31.200	9360.00	40000.00	35.600	10680.00
	Four-Valve	28	33600.00	26.210	7864.00	33600.00	29.890	8968.00
	Corliss	25	30000.00	23.380	7016.00	30000.00	26.690	8008.00

—Nagle Corliss Engine Works

STEAM CONSUMPTION OF ENGINES

Horsepower of Engine	Throttling Engines, Simple Single-Valve: 75 lbs. I. P.	Throttling Engines, Simple Single-Valve: 100 lbs. I. P.	Corliss Engines, Simple: 90 lbs. I. P.	Corliss Engines, Simple: 110 lbs. I. P.
60	50 to 52	48 to 50	26 to 27	25 to 26
75	50 to 52	48 to 50	26 to 27	25 to 26
100	50 to 52	48 to 50	25 to 27	24 to 26
150	48 to 50	46 to 48	25 to 27	24 to 26
200	48 to 50	46 to 48	25 to 27	24 to 26
250	48 to 50	46 to 48	25 to 27	24 to 26
300	44 to 46	42 to 44	25 to 27	24 to 26
400	44 to 46	42 to 44	24 to 25	23 to 24
500	44 to 46	42 to 44	24 to 25	23 to 24
600	40 to 42	38 to 40	24 to 25	23 to 24
700	40 to 42	38 to 40	24 to 25	23 to 24
800	40 to 42	38 to 40	24 to 25	23 to 24

Approximate decrease for Condensing Engines. 26" Vacuum. ¼ C. O.

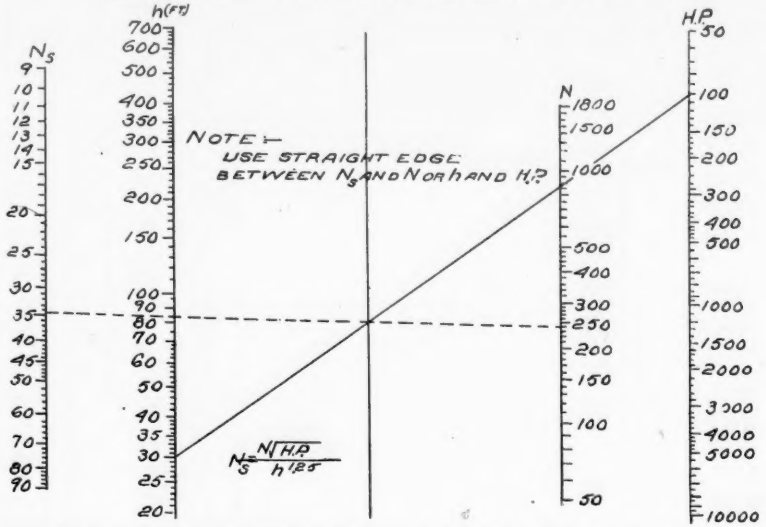
Pounds Pressure	Per Cent Saving
100	23
125	20
150	18

NOTE:

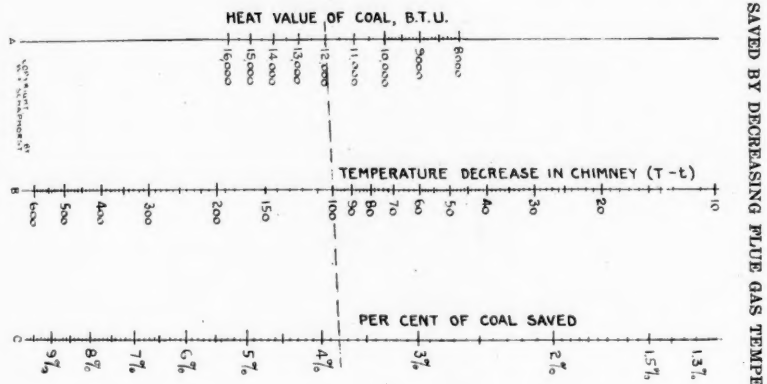
The above table does not allow for steam used to operate condenser and pump the cooling water.

—Nagle Corliss Engine Works

RELATION BETWEEN CHARACTERISTIC SPEED, REVOLUTIONS PER MINUTE, HEAD AND HORSEPOWER OF HYDRAULIC REACTION TURBINES



COAL SAVED BY DECREASING FLUE GAS TEMPERATURE



Due to the general enthusiasm and particularly to the efforts of the campaign committees, many departments were able to display "100 per cent" signs; where one or two persons hung back, the force of public opinion quickly brought them into line.

About 1200 of the company's women employes marched in the Liberty Loan parade in Pittsburgh on April 20, banners designating their work, and were accompanied by both the brass and bagpipe bands.

THE CHICAGO BRANCH of the Clarage Fan Co., of Kalamazoo, Mich., has been removed to the Conway Bldg., 111 W. Washington St., Room 1666. Gardner J. Thomas is in charge of the Chicago office.

YARNALL-WARING CO., Chestnut Hill, Philadelphia, announces that G. A. Binz, formerly manager of the Meter Department of the company, has been appointed sales manager.

ALBERT TATE SMITH, lately manager of the R. U. V. Co., 50 Broad St., New York City, has returned to the Permutit Co., with which he was formerly connected, to take the position of assistant manager of sales.

THE Smith Gas Engineering Company announces its removal, on April 15, into its new factory at Dayton, Ohio, where the main offices of the company will be located. The factory at Lexington will be operated as usual on certain class of work. To secure prompt attention all correspondence hereafter should be addressed to Dayton.

Books and Catalogs

BUREAU OF MINES announces the following among new publications now ready, only a limited supply of these being available for free distribution: Bulletin 137, The Use of Permissible Explosives in the Coal Mines of Illinois, by J. R. Fleming and J. W. Koster; Bulletin 148, Methods of Increasing the Recovery of Oil from Sands, by J. O. Lewis; Technical Paper 141, Laboratory Determination of the Inflammability of Coal Dust and Air Mixtures, by J. K. Clement and C. N. Lawrence; Technical Paper 181, Determination of Unsaturated Hydrocarbons in Gasoline, by E. W. Dean and H. H. Hill. Publications should be ordered by number and title, addressing applications to the Director of the Bureau of Mines, Washington, D. C.

ELECTRICAL EQUIPMENT in the Woodworking Industry, is the title of a circular just issued by the Westinghouse Electric and Manufacturing Co. The publication is profusely illustrated by views of motor-driven woodworking machinery both alone and as installed in representative woodworking plants. Starting with the general subject of motor drive, the reasons for its adoption, such as increased production, better light, greater safety to employes, higher efficiency of machines, more accurate knowledge of cost and greater freedom in power distribution are explained. The next section is devoted to features of Westinghouse motors which make them suitable for this work, such as rigid construction, sparkless commutation of direct current machines, and simplicity and reliability of oiling. Assistance which may be rendered to owners of woodworking plants is described; this includes advice as to layout of plant and proper motors to use, and prompt repair service in case of breakdown. The woodworking plant of Ferguson Brothers Co., Hoboken, N. J., is described and illustrated in a third section. It manufactures furniture and wooden novelties of various kinds, and is completely motor equipped. The rest of the book gives horsepower requirements and other data for many different sorts of woodworking machinery which will be of much value to those having to do with this class of industrial activity.

Copies of this circular will be sent on request to any Westinghouse district office.

THE WHEELER Condenser & Engineering Co., of Carteret, N. J., has just published its Bulletin No. 108-B embracing exclusively the company's line of centrifugal pumps. The bulletin shows the latest Wheeler turbine-driven geared centrifugal pumps, bi-rotor, tri-rotor, electric-driven, small belt-driven, small high-speed, side, end and bottom suction; vertical shaft; pumps for either series or parallel operation, and special slow-speed engine-driven pumps. Test curves made by both manufacturer and customer are included in the bulletin, giving the characteristics of Wheeler high-grade design. Wheeler pumps are made for all services and especially for installations where large volumes of water must be pumped economically against low heads.

OAKITE, for cleaning waste and wiping cloths is described, and the methods of use illustrated in a booklet issued by the Oakley Chemical Co., 22 Thames St., New York City. It is claimed that this material produces, after the washing, waste and cloth that are more absorbent and better than new, as well as being free from lint. The small tank outfit washes 30 to 40 lb. of waste at a time, or 300 lb. a day. The large tank takes 200 to 300 lb. at a time, or 1200 lb. a day; and the laundry wheel takes 100 lb., at a load, or 600 lb. a day. The booklet can be had on application by mentioning Power Plant Engineering when writing.

A NEW PIPE TOOL CATALOG, No. 38, which is being sent out by Greenfield Tap & Die Corporation, Greenfield, Mass., is a revised and completed edition of the first catalog of this number, which was issued some time ago, and deals with the complete line of the company's pipe tools.

YOU'LL ENJOY reading it for it is a cleverly written little story. It's called The Tale of a Pound of Steam, and is published and circulated by the Ashton Valve Co., 161 First St., Cambridge, C., Boston, Mass. It can be had on application; takes but a few minutes to read; has no moral and is complete in one volume.

BULLETIN NO. 30, entitled Automatic Reclosing Circuit Breakers and Relays, for the protection of direct-current circuits, has just been issued by The Automatic Reclosing Circuit Breaker Co., Columbus, Ohio.

THE GENERAL ELECTRIC CO., in Bulletin No. 46,030, describes the latest portable types of current transformers, cable testing current transformers and potential transformers.

Compactness, flexibility and light weight have been maintained in the manufacture of these portable testing instruments consistent with the highest accuracy.

This bulletin, which is fully illustrated, contains valuable information, together with sample data sheets and current price lists for the purchase and use of these convenient transformers.

FROM CROUSE-HINDS CO., Syracuse, N. Y., we have received Bulletin No. 1E, Supplement to Bulletin No. 1, on the subject of residence panel boards.

THE LATEST CIRCULAR relating to "Ohio Brass" gate valves has just been received from The Ohio Brass Co., Mansfield, Ohio.

INDEXES TO General Electric Co. descriptive bulletins and sheets, and supply part bulletins, are being sent out by that company.

AN ILLUSTRATED FOLDER relating to Homestead three and four-way valves was recently received from Homestead Valve Mfg. Co., Homestead, Pa.

AMERICAN FIRE CEMENT CO.'S circular gives directions for the use of American fire cement in manufacturing plants, foundries and forging. The company's address is 468 Lisbon St., Lewiston, Me.

LINK-BELT Roller Chain Book, No. 358, has just been issued by Link-Belt Co., of Chicago, to give preliminary information on recent roller chain development, pending the revision of the company's Roller Chain Data Book.

THE STETS boiler-feed controller with V port valves, is the subject of a booklet discussing its development, method of installation, valve and float design, and advantages in design. The maker is The Williams Gauge Co., of Pittsburgh, Pa.

Trade Notes

THE SPRAGUE ELECTRIC WORKS of General Electric Co. announces the removal of its St. Louis office from the Chemical Building to Pierce Building, St. Louis, Mo. The company takes this opportunity to express its grateful appreciation of the constant increase in business in this section and to assure old and new customers that orders will continue to be filled with the same high quality of product.

THE HAVARD COAL METER, which has been in general use for a number of years for measuring coal in boiler rooms as fed to boilers, has been awarded the Certificate of Merit by the Franklin Institute of the State of Pennsylvania.

The award reads as follows:

"In consideration of the invention of a meter for the measurement of granular material, which combines simplicity of construction with reliability in operation, is automatic in action and accurate in measurement within a reasonably small limit, the Institute awards the Certificate of Merit to Oliver D. Havard, of Allentown, Pa., for his invention of the Havard Coal Meter."

(Signed) GEO. A. HOADLEY, Acting Secretary.

(Signed) WALTON CLARK, President.

(Signed) H. JERMAIN CREIGHTON, Chairman of the Committee on Science and the Arts.

POWER PLANT ENGINEERING

Trade-mark, Reg. U. S. Pat. Off.

(Established over 22 years.)

PUBLISHED THE FIRST AND FIFTEENTH OF EACH MONTH

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Member Audit Bureau of Circulations.

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Full page, one year, each insertion, $66.00.

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Three line parallel 3-point border rule used.

Stippled plates used, but no heavy, black and white plates.

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Per line, 30 cents each insertion.

Advertisements in this section are inserted under regular headings.

No display type allowed, but the first three words may be set in capital letters.

About nine words make a line. Minimum space sold, two lines.

Under classification "Position Wanted," advertisements not exceeding four lines will be inserted once for subscribers free of charge.

All copy and cuts should be received at Chicago Office eighteen days prior to date of publication.

Circulation of this issue, 23,700.

Technical Publishing Company

537 S. Dearborn Street,
Chicago

Position Wanted

POSITION WANTED—By master mechanic familiar with gas and steam engines, boilers and electrical machinery; capable of taking complete charge of mechanical end of large factory; 17 yrs'. experience. Age 37 yrs. Sober and in perfect health. At present employed as master mechanic of factory. Desires change on account of not liking the East and will consider only the West. Address Box 523, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 5-15-1

POSITION WANTED—As engineer in small plant; 10 yrs'. experience with Corliss and high speed engines. Familiar with d.c. generators and gasoline engines. Age 34. Married. Strictly sober and good repair man. Address F. H. Daton, 2823 Calumet Ave., Chicago, Ill. 5-15-1

POSITION WANTED—As chief engineer, 13 years' experience with Corliss and high-speed engines, electrical and refrigerating machinery. Sober and reliable. Best of references. Address Box 518, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 4-1-2

POSITION WANTED—To take charge of plant as superintendent. A1 electrician. Salary $150. For further particulars write Box 520, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 5-15-1

POSITION WANTED—By a first class man, aged 35, married, strictly sober, reliable and energetic. For the past 7 years superintendent of water, light and power plants, capable of doing any kind of work in steam or electrical engineering, meter repairing or testing, line work or inside wiring. Especially capable of managing water and light plant properties. Prefer a field where there is a chance of advancement. Address Box 522, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 5-1-2

POSITION WANTED—As oiler or assistant engineer in a power plant around New York City; 1 yr. experience as student and assistant to engineer. A. J. Benora, 38 Park Hill Ave., Yonkers, N. Y. 5-15-1

Help Wanted

WANTED—Resident subscription agents in the following cities: Atlanta, Ga.; Cincinnati and Columbus, O.; Kansas City, Mo.; Los Angeles, Cal.; Louisville, Ky.; Newark, N. J.; New Orleans, La.; Portland, Ore.; St. Louis, Mo.; San Francisco, Cal.; Washington, D. C. This is an excellent chance for a hustler, who is familiar with power plant conditions, to turn his spare time into dollars. To such a one we offer a Real Opportunity. Write Subscription Department, Power Plant Engineer, 537 S. Dearborn St., Chicago, Ill. tf

WANTED—A competent refrigerating engineer in Western Pennsylvania. Must be familiar with raw water and ice making system and electric machinery. State salary wanted. Address Box 505, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. tf

WANTED—A competent electric light engineer, familiar with Corliss engines, 12-hour shift. Good working conditions. Salary $85.00. Fuel consumption 2½ tons per shift. No boiler washing. Address L. F. Haupt, superintendent, Prairie du Chien, Wis. tf

WANTED—Engineer to take charge of 12-ton ice machine and small eletrical equipment, all of which is high grade. A steady and lasting position for a clean, sober man. Salary $100. Write Andrew Lohr Bottling Works, Cairo, Ill. 5-1-2

WANTED—An experienced engineer and elevator man. One who makes coils, repairs armatures and operates Otis elevators and also understands steam heating and cold water systems for an office building. E. N. Brackenridge, 715 Brady Bldg., San Antonio, Tex. 5-15-1

WANTED—Motor-driven ice machine, 50 to 80 tons. State make, price, etc. A. Fink & Sons, Newark, N. J. 5-15-2

Wanted

WANTED—Agents on commission to sell our shaking grates. We will install grates on trial to put it to test at our expense with any grate made. Address Armstrong Mfg. Co., Springfield, O. tf

WANTED—Agents handling engine and boiler room specialties in every section for side line paying large commissions. Give experience, line carried and territory covered. Box 381, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. tf

WANTED—Marine boilers. We will pay cash awards for information that leads to a purchase by us of marine boilers of from 75 hp. to 250 hp. The Pittsburg Boiler & Machine Co., Pittsburg, Kan. tf

WANTED—Agents handling engine and boiler room specialties in every section of our Boiler Girth Seam Protector. Liberal inducements. Give experience and territory covered. Address National Boiler Protector Co., Dayton, Ohio. tf

WANTED—Engineers in their spare time and salesmen who carry side lines and visit engineers to sell the Selden and Zena packings. Both packings have shown their worth by use in largest plants. Randolph Brandt, 70 Cortlandt St., New York. 3-15-6

AGENTS WANTED—Salesmen calling on power plants to handle established nationally advertised product backed by a direct-by-mail campaign that "follows through" liberal commission. Write today for our proposition. Box 521, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 4-15-2

WANTED—Agents who call upon engineers to sell positively the best pump valve on the market. Commission basis. Excellent. Address Box 500, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 5-1-2

For Sale

FOR SALE—Boilers: 305 hp. and one 225-hp. Heine water tube boilers, in battery, 175 lbs. Hartford insurance. With stokers. Practically new; installed 1912, 2 yrs'. service, $10,000. Power Machinery Exchange, Jersey City, N. J. tf.

FOR SALE—Boilers, two 300 hp. Freeman internal fired, 125 lbs. pressure. Fixture complete. Immediate shipment. Make us a price. Mitchell Motors Co., Inc., Racine, Wis. 5-15-2

Patent and Patent Attorneys

PATENTS THAT PROTECT AND PAY—Advice and books free. High references. Best results. Promptness assured. Send sketch or model for search. WATSON E. COLEMAN, Patent lawyer, 624 F St., N. W., Washington, D. C. tf

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. Washington, D. C. tf

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had and the exact costs. Send for full information. tf

A. P. CONNOR, Consulting Electrical and Mechanical Engineer, Attorney-at-Law and Solicitor of patents and Trade-Marks. Results guaranteed. 121 Carroll St., S. E., Washington, D. C. tf

PATENTABLE IDEAS WANTED—Send for three free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. tf

Technical Books

FREE ENGINEER BOOKS and power plant tools and specialties, for securing new subscribers for Power Plant Engineering. A dandy chance for the engineer with a little spare time to get some fine premiums. Send for free descriptive circular and terms. Subscription Department, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill.

Miscellaneous

FACTORY MANAGERS, ENGINEERS AND OWNERS—Coal is high and scarce. Let us tell you how to conserve it and utilize your exhaust steam for heating and drying purposes. Address Monash Engineering Co., 1413 W. Jackson Boulevard, Chicago, Ill. tf

DEBTS COLLECTED QUICKLY!—Established 25 years same address. William H. Dodd, 87 Nassau St., New York, N. Y. 5-1-2

YOU CAN SAVE 10 to 50 per cent of your coal bill by utilizing exhaust steam to heat boiler feed water, to warm buildings, to dry materials, etc., and by keeping the boilers free of soot and scale, stopping up air leaks in boiler settings, repairing baffles, adopting more scientific methods of firing and regulating draft and purchasing your coal more intelligently. The latest and best data on steam plant economy has been specially compiled for the use of owners, managers, designers, engineers and firemen in the Cochrane Coal Savers' Manual, "Finding and Stopping Waste in Modern Boiler Rooms"; 274 pages, 213 charts and diagrams, bound in flexible cloth; price $1.00. Harrison Safety Boiler Works, 3144 N. 17th St., Philadelphia, Pa.

Bids Wanted

BIDS WANTED—City water pump. The City of Charleston, Ill., is in the market for a new compound duplex water pump; for the purpose of a water system. Sizes, 14 by 20 in.; 13 by 18 in. 2,000,000 gallons per day capacity. Bids received until June 4, 1918. For further particulars inquire. Frank J. Trimble, City Clerk, Charleston, Ill.

Sparks From The Advertising Pages

Where Buyers and Sellers Meet

From the Bowl Running Over

Every true American is living his life for his country these days—living it or giving it.

From our overflowing bowl of wealth we are asked to give—give from the overflow—the waste.

This calls for a more exact care of the drops that make up our abundance. Every dollar now spent is an investment for or against world liberty.

What is waste? What is economy? How shall we invest?

From an investment standpoint waste is that expenditure of money that produces nothing for the investor or for the nation.

The farmer invests a hundred dollars in corn to plant his land. He may reasonably expect a production of thirty-fold, sixty-fold, perhaps a hundred-fold.

But if this farmer does not invest in a hoe his crop will be overcome with weeds.

He will lose his investment in seed, in plowing and planting, and he loses the use of his land. And the nation loses the amount of his loss and loses the thousands of bushels of food that should have been produced. Civilization itself is set back a step by this wasted investment.

A business man invests many multiples of a hundred dollars in a power plant. He buys a boiler, an engine, and builds structures to hold them. But until he has connected up his last pipe, until fire roars through the flues and steam whirls the fly-wheel, and power is developed to help lift the drudgery from the back of mankind, his investment is dead.

But the farmer who buys seed that will not germinate; who lets his hogs die to save the cost of cholera treatment, is a traitor to himself and to Liberty's cause.

And the man who fails to equip his power plant to the newer standards of efficiency is hindering the onward march of Victory.

Investments that will make coal burn better; that will transmit steam with less loss; that reduce the drag of friction, are investments in the right of humanity to "life, liberty and the pursuit of happiness."

Save at every possible point on wasteful expenditure. This creates capital.

Invest every possible cent in things which will produce; which will further reduce waste; which will create more capital.

Every exploding American shell plows a furrow from which freedom sprouts —if we send enough of them. Less than enough, and the whole investment of money, blood and tears is lost. Less than enough, and the bounteous increase of liberty down through the generations is lost.

Invest in the perfected tools of your profession—the equipment that will **save** waste; release men; help win the war.

Advertisers in the pages of "POWER PLANT ENGINEERING" offer you this superior equipment—the means to eliminate waste in your plant.